The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIII No. 7. JULY, 1952

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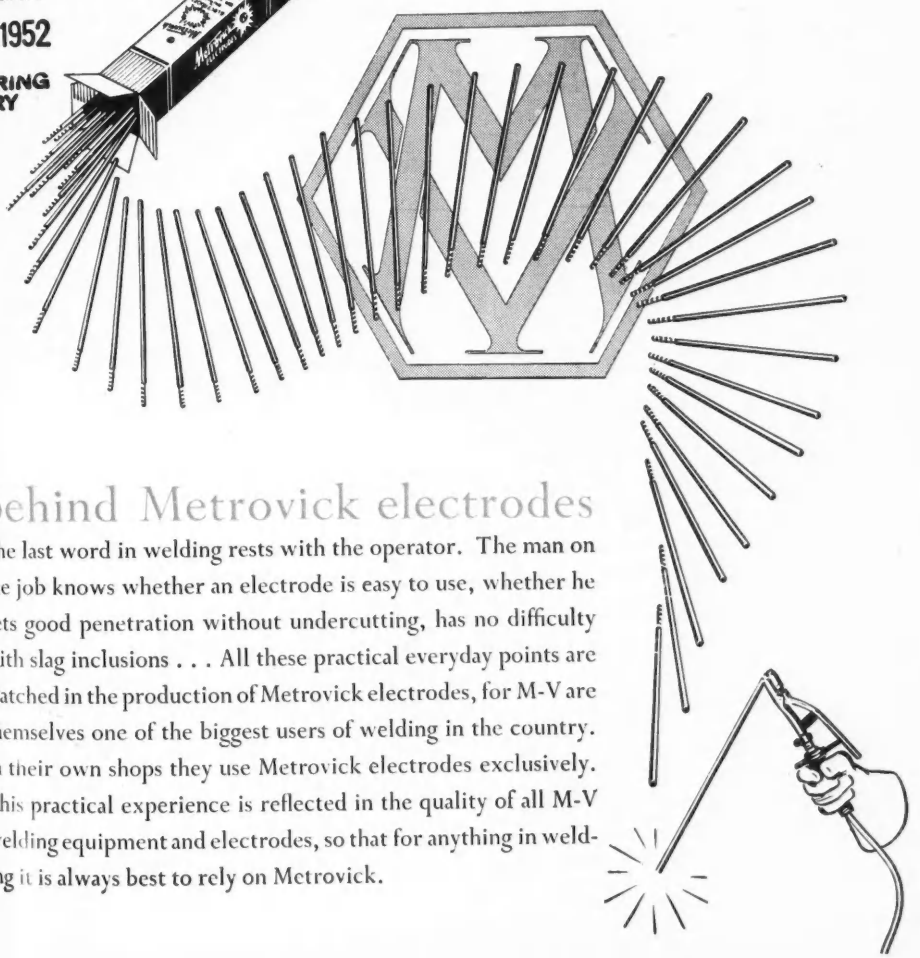

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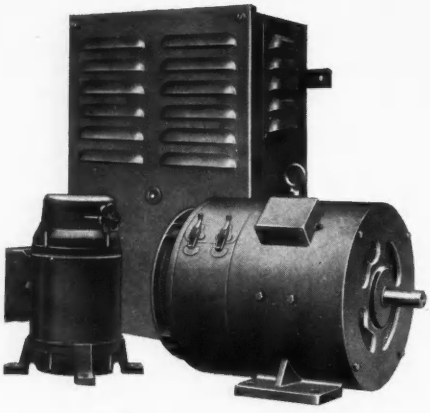

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *STEAM-COOLED ALTERNATOR*

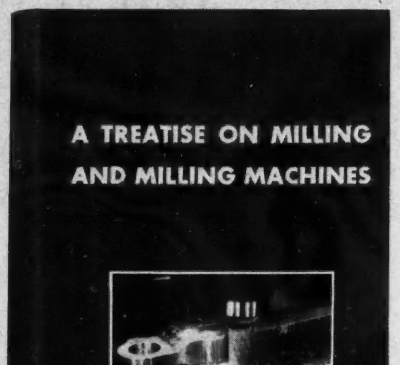
A water-vaporisation cooled alternator for aircraft use has been developed which is reported to give trouble-free operation under extreme conditions of temperature and altitude. The development of this unorthodox type of equipment was necessitated by the fact that high-speed flight and high altitude cause a rise in the cooling air inlet temperature of electrical machinery and, therefore, impose limitations on conventional alternators cooled by air blast or fan action. Major design problems were introduced by the adoption of a cooling system of this type because of the high-temperature, high-vapour content atmosphere produced by the evaporation of water in the machine. Bearing and brush performance are, in particular, liable to be adversely affected by such an atmosphere. In fact, a minute amount of water vapour in the race area of the ball bearings can cause a speck of rust to form which will destroy a 12,000 rpm bearing in a matter of seconds. Vapour-tight seals and special high-temperature grease had therefore to be introduced in order to provide the protection necessary to safeguard long bearing and brush life. In operation, coolant from a reservoir is injected into the hollow shaft of the alternator under pressure. The centrifugal force acts to spray the water through four ports and thus scatter it on the internal surfaces of the machine. The heated water evaporates to become the coolant and the resultant steam is exhausted through a port. The water supply is automatically controlled by a special valve which is actuated by a temperature-sensing element located in the stator iron.

● *PORCELAIN-ENAMEL ADHERENCE*

A ceramic or porcelain-enamel coating, to be effective, must adhere firmly to the metal it is designed to protect. Cobalt oxide is known to promote effectively the adherence of porcelain-enamel to iron, and for this reason has long been added to enamel ground-coats. Despite a great deal of research, however, the mechanism by which cobalt oxide promotes adherence is not yet well understood. By adding radioactive cobalt as a tracer to the frit used in the coating, it has now been possible to obtain a certain amount of information on the nature of the process involved. It was found that a metallic cobalt layer was formed at the enamel-metal interface, and that near the interface the enamel layer was depleted in cobalt oxide. The amount of cobalt which thus migrated to the interface increased with increased firing, although the total quantity involved was extremely small, being equivalent to a layer of metallic cobalt of the order of 0·01 micron for normal firing. Substantial penetration of the iron base by the cobalt was observed in a coated specimen which was heated in air at 1300° F for 270 hours, after normal firing. The cobalt deposit is believed to be metallic because it could be removed with the iron base metal during an iodine-potassium iodide treatment, but not completely removed by 65 hours of treatment with ammonium citrate. These investigations must be considered to constitute a typical example, among many, of the importance attaching to diffusion processes in metal treatment, and it is hoped that they will act as a stimulus to intensified research in this extremely important field.

● *HALL EFFECT MOTOR*

It is known that a plate of certain materials such as, for instance, germanium or bismuth, when cut by a magnetic field flux through its plane and passed by a current through one axis of its plane, will produce a voltage across the other axis of its plane at right angles to the input current axis. This phenomenon shows definite polarity effects, depending upon the direction of the magnetic flux and of the input current. This phenomenon is known as the "Hall effect," which, as many other phenomena of a similar nature, has found its place in text books as an interesting physical phenomenon without, however, any reference being made to its possible practical applications. A recent patent specification points out that with the use of such Hall plates of the aforementioned materials, a motor device can be constructed which constitutes a direct current motor supplied by alternating current, in which both commutation and rectification functions are performed without moving contacts. This motor is used for rebalancing the potentiometer of a temperature recorder, in which the voltage of a thermo-couple is compared to a voltage from a standard cell. The error voltage produced is converted to alternating current in the usual manner and then fed to the Hall type motor, which is then made to operate in accordance with the polarity and magnitude of the original direct current signal



The nine-hundred pages of the TREATISE ON MILLING AND MILLING MACHINES are packed with authoritative data, illustrations and charts on the process of milling and the related field of cutter sharpening. It records the accumulated experience of the Cincinnati team of technicians over a period of 67 years. The headings of the various chapters shown in the "Table of Contents" indicate that this publication is invaluable to all who are engaged in the Metal Working industry.

Treatise on Milling and Milling Machines

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PREFACE

Chapter 1 The Milling Machine

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The "Treatise" is published in U.S.A. at the price of Eight Dollars.
Information regarding procurement of the book in this country may be obtained from :—

Cincinnati Milling Machines Limited, Birmingham, 24

voltage. The action of the motor thus serves to rebalance the potential in a direction to reduce the error signal to zero. There should exist many other interesting possible applications of this nature and further developments will be awaited with interest.

● *PHOTOCHEMICAL METHOD OF WORKING GLASS*

An extraordinarily interesting new photochemical method for the working of glass has just been announced. The new method takes advantage of the transparency of glass to produce a pattern in the material either on the surface or through the thickness of the piece and then, by means of a differential chemical etching procedure, dissolves away the part of the glass modified by light to free the form desired. This process utilizes the properties of a special type of glass which is photosensitive to ultraviolet light. The first step in the photochemical forming process is to produce a template or mask in which the open areas correspond to the portions of the glass to be removed. Actual processing begins with exposure of the glass, with the mask covering it, to ultraviolet light. The next step consists of heating the irradiated glass in an oven at about 1200° F for a period of about 1 to 2 hours. The heat treatment brings out a milky pattern corresponding to the shape of the mask, the remainder of the glass remaining clear. The milky portion of the glass is about fifty times as soluble in hydrofluoric acid as the clear portion. The entire piece is immersed in a dilute solution of hydrofluoric acid, and the differential rate of attack causes the milky portions to be dissolved so fast that the clear portions remain practically unaffected by the acid. The process thus makes possible the perforation of a piece of glass with holes of any shape and size. Electrical circuits can also be etched into the surface of a plate and filled with metal.

● *SALVAGING SCRAP CARBIDE*

It is reported that a carbide salvage programme established in the works of one of the largest electrical manufacturers in this country has eliminated 78 per cent of the loss of this valuable and scarce material. Secondary savings in terms of increased service life of jigs, fixtures and gauges are claimed to more than compensate for the cost of the other 22 per cent. Worn tools and fragments of broken tools are reclaimed for re-use. They may be re-used as cutting tools or used at points of wear in fixtures, dies and gauges. It is estimated that 65 to 70 per cent of the original cost of all carbide scrapped is thus recovered. Even pieces which are too small to be re-used are utilized by crushing them for use in abrasive compounds. The first objective is to re-use tipped tools where possible. By regrinding or adaptation of rakes and cutting edge forms, many tools can be saved for further cutting use. It was found, for example, that about 34 per cent of all broken tipped lathe tools could be reconditioned for use as light finishing tools. Tools which cannot be reconditioned have their tips removed and added to the collected fragments, while the shanks are reconditioned for new tips. Prior to re-use, all pieces are checked for cracks or other flaws. This is done visually with a magnifying glass, but where doubts as to soundness exist, the parts are heated to a dull red in a small muffle furnace to prevent oxidation. Minute cracks then are more plainly revealed as dark lines, usually visible to the naked eye.

● *ELECTRO-MECHANICAL MANUFACTURE OF BEARING BALLS*

According to a Russian report, an electro-mechanical method of grinding bearing balls has been introduced into production which eliminates all except the final stages of the ball manufacturing process. Moreover, the new method is claimed almost to halve production time. The balls to be ground are introduced between the two electrode discs of the machine by passing them through a hole in the centre of the upper disc and they leave this space at the periphery. These discs are electrically insulated from each other and from other parts of the machine. The upper disc, which is stationary, consists of three sectors, which are connected to the terminals of a three-phase transformer capable of supplying some 1500 amps at 20 to 25 volts. The lower disc has a smooth surface and is rotated at a speed of some 500 rpm. The space between the discs is flooded with an electrolyte, usually water, and the machining action is produced by the numerous quenched arcs resulting from the random contacts taking place between the balls and the electrode surfaces, several balls acting together to complete the bridge between the upper disc sections of different polarity. Owing to the constant change in the points of contact, the surface of the balls is worn away gradually in a uniform manner so that a true spherical shape is produced. As the arcs burn shallow pits in the surface and also produce a decarburized layer, a subsequent mechanical finishing process is required. This consists in the lapping of the balls, but it is also possible to operate the machine at a lower voltage so that a smooth spherical surface is produced.

● *FINISHES FOR POWDERED METAL PARTS*

The more general utilization of parts made from metal powder, especially iron powder, has been retarded by the inability of securing a surface finish which is both corrosion-resistant and pleasing in appearance. The inherent porosity of most structural parts made from metal powders generally precludes the application of electroplating, as this process requires a surface which is virtually free of pits, pores and other blemishes

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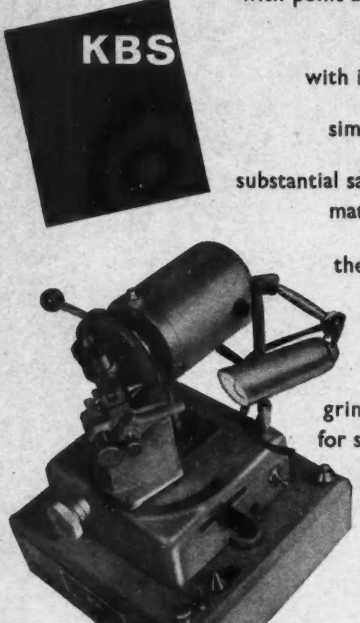

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that will impede the formation of a smooth deposit. The part must also be sufficiently non-porous so that there will be no entrapped plating liquor which can later cause discoloration or blistering. As a rule, a density of the part of 85 to 90 per cent of the theoretical value must therefore be considered the lowest practical limit for electroplating. One of the newer methods of metal finishing which is now being successfully applied to parts made of metal powder is the electrolysing process. In this process, a film of hard chromium alloy is deposited by evaporation on all surfaces of the part being treated. Generally, the evaporation is carried out in a closed chamber at very low pressures and the metal to be evaporated is heated to its boiling point at the pressure employed. The film thickness can be varied from about 30 microinches up to 0·002 inch. The film deposited has about 79 to 81 Rockwell hardness and is of a uniform thickness at all places. Unlike electrodeposited coatings, there is no tendency to build up at corners or on sharp edges. Extreme care must, of course, be taken to clean and dry the part thoroughly prior to electrolysing.

● *NOVEL STOKER TYPE*

An annular type of stoker has been placed on the market in which the grate consists of three eccentrically arranged rotating rings, each of which is covered with grate bars. There is a central hole closed with a gate through which the ash is discharged periodically. The coal is admitted tangentially to the periphery of the stoker and, owing to the motion of the stoker annuli, is gradually passed to the centre of the stoker. While the new design does not appear particularly suitable for water tube boilers, it may prove of value in connection with cylindrical boilers, but, of course, it requires a special refractory furnace, as it cannot be installed in the boiler flues. The underlying aim of this invention is apparently the development of a stoker capable of firing a wide range of low-grade fuels, and for this reason alone closer scrutiny of this stoker design may prove of interest. The inventor claims that high combustion efficiency can be obtained with such low-grade fuels as lignite fines and bituminous coal sludge containing 31 per cent moisture and 36 per cent ash, without requiring the addition of any other fuel. It is also claimed that very high specific grate firing rates can be achieved with this design, and that replacement of existing stokers by the new type will permit an increase in the rate of evaporation of the boiler. Another claim is that the capital cost of the new type is lower than that of existing travelling grate stokers and that it is superior to the latter type because it precludes the ingress of air at the stoker periphery owing to the efficient sealing of the clearance by the coal itself.

● *CAST FORGING METALS*

In the manufacture of metallic articles, situations frequently arise where neither of the conventional processes of casting or forging is entirely satisfactory. Thus, it may be desired to produce an article of a shape lending itself to casting rather than to forging from a metal which lends itself to forging rather than to casting. Most castable metals are entirely non-malleable, and most malleable materials cannot be cast. It is therefore obviously desirable to have a method available which would combine the casting and forging treatment of metals and alloys. Various attempts have been made in the past to develop such a method of " cast-forging " in which the metal is cast between dies constructed so as to exert simultaneously a forging pressure on the solidifying metal. A recent invention proposes to pour a quantity of molten metal into a lower die, and then to close the lower and upper die upon the metal in a two-stage movement. The second stage of this movement is to be performed at considerably lower speed than the first stage, and it is to be suddenly initiated at a point of the closing stroke of the die where the volume of the space between the dies is slightly larger than the volume of the molten metal. In order to prevent undue cooling of the metal contained in the lower die which would lead to its premature solidification, it is proposed to apply a fine powder having heat-insulating and lubricating properties to the metal-wetted surface of the lower die or to the surfaces of both dies.

● *SOLDERING CERAMICS TO METAL*

Where air- or gas-tight joints have to be made between a ceramic and a metal as, for instance, in spark plug manufacture, patented methods are available which make it possible to produce a soldered bond between metal and ceramic. In one such method, the ceramic body is coated with a titanium-copper alloy, by applying a mixture of titanium hydride and powdered copper and then heating the piece in an atmosphere of pure dry hydrogen until the titanium hydride dissociates. This results in the release of hydrogen and an alloy of titanium and copper is formed as a coating on the ceramic body. The mixture of titanium hydride and powdered copper is applied in a volatile liquid which can be painted or sprayed onto the ceramic body. Soldering can then be carried out by applying solder to the coating. This solder is generally a silver-base solder or a copper-base solder, but may even be pure silver or pure copper. If the solder is used as a powder, it can be mixed with the titanium hydride and applied with it at the same time. It should be a high melting point solder because it must melt at a temperature within the range in which the titanium hydride decomposes and gives off enough hydrogen to protect itself from oxidation. When carrying

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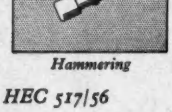

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out the soldering in a furnace, the latter is filled with pure hydrogen which has first been passed through a palladium catalyst to change its oxygen contents to water, whereupon the hydrogen is dried in a drier employing aluminium oxide as drying agent. In some cases it may be preferable to effect the soldering in a vacuum furnace, so that the joint is free from occluded gases.

● *IMPROVING QUALITY OF WELDS*

There exist numerous occasions in welding practice where the use of metal base plates must be resorted to in the welding of seams. Recent research indicates that iron powder backing materials may have several important advantages over the steel or copper bars usually employed for this purpose. In fact, copper base plates do not eliminate defects at the root of the seam. Due to their rapid heat dissipation they cannot counteract the hardening of the base metal at the welding zone; and they may also cause serious warpage. Good backing material for welds should eliminate the necessity of chiseling out and rewelding the root of the seam, should counteract the hardening effect of a rapid heat dissipation, and should be easily removable. It is claimed that this has now been achieved by the development of a base material for welds which consists of iron powder of definite grain size. To keep the powder in place, narrow channels of thin sheet metal are filled with tightly pressed iron powder, or the powder is compressed into flat bars of proper cross-section which are slightly sintered. The use of iron powder for this purpose is claimed to be of equal advantage in the automatic machine welding method. Grain sizes up to 0·008 in. are most suitable for both the pressed and the compressed type of weld base materials. Compressed or slightly sintered backing bars result in better-looking welding seams and, if the root layer is to be removed, require less rewelding than bases of hand-pressed powder.

● *METAL REINFORCED CERAMIC PARTS*

A recent invention outlines a method by which ceramic components for high-temperature applications such as gas turbine blades can be internally reinforced by a structure of high temperature resistant metal. It is obvious that the metal to be used for this purpose must have a melting point higher than the softening point of the refractory which it is to reinforce and protect. The proposal of reinforcing ceramic bodies in this way, of course, is not new, but considerable difficulties were experienced in practice. These difficulties were due to the penetration of oxygen through the refractory with attendant attack of the metal by corrosion, or reaction of the metal with the refractory material, or its volatilisation as, for instance, in the case of molybdenum and tungsten. The new method aims at precluding these effects by casting about the metallic structure a completely impervious or gas-tight ceramic envelope, and effecting its firing or sintering in a vacuum or a reducing atmosphere. The refractory material used for this purpose may, for instance, be alumina in the form of a fine slip. This is applied to or cast round a molybdenum wire, and after air drying at room temperature is heated to 1750-1800° C in a furnace evacuated to approximately 0·005 mm mercury. Among the advantages obtained by this method of reinforcing ceramic bodies are increased resistance to thermal shock and elimination of distortion in the moulded sections during drying, thus aiding precision moulding. This method can also be used for manufacturing heating elements for temperatures of the order of 2000° C in which the current passes through the internal wire until the element has reached a temperature at which the ceramic becomes electrically conductive.

● *COMBATING FRETTING CORROSION*

Fretting, which is defined as a surface failure which may occur when closely fitting surfaces experience slight relative motion, damages many machine parts subject to vibration. It is principally characterised by surface stains, pitting, and the generation of oxides. Recent tests carried out on an extensive scale have definitely proved that fretting is principally a physical phenomenon; any chemical action taking place is strictly a secondary factor. The commencement of fretting was found to be independent of vibratory motion; it does not require a great amount of relative motion, nor does it take a high rate of speed to cause fretting. It appears that fretting is initiated by the loosening, due to inherent adhesive forces, of extremely finely divided and apparently virgin material that is extruded and reacts with oxygen simultaneously. Introduction of oil between the surfaces increased fifty-fold the time for the first evidence of fretting action to appear. Once the action had started, however, the modifying effect of the oil was reduced. Many different lubricants were tried and molybdenum disulphide was found to be most successful in mitigating damage due to fretting. The best way of applying this lubricant is bonding it to the surface to be protected. By employing resin-forming viscous liquids such as asphalt base varnish, the molybdenum disulphide can be bonded to materials such as steel, aluminium, brass, stainless steel, and glass. The important conclusion is drawn that, although fretting cannot be entirely eliminated, in some cases it can be retarded to such an extent as to become a negligible factor.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.

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VOL. XIII. No. 7. JULY, 1952

Iron and Steel Making in the U.S.A.

The higher productivity of both plant and labour in the American heavy steel industry may be attributed mainly to larger units of plant in larger works, the greater purity and abundance of raw materials, faster driving of plant and the use of high-grade fuel, including oil and natural gas. These are the broad findings of the British Iron and Steel Productivity Team which spent 5½ weeks visiting heavy steel works in the United States last year under the auspices of the Anglo-American Council on Productivity and the E.C.A. technical assistance programme.

The market served by the British industry is only one-sixth as large as the American and, because of the larger proportion of exports, is much less standardised. In America, the ranges of product size and qualities have been substantially reduced, and broader tolerances and less rigid specifications of finish encouraged, by charging larger extras for special qualities and small quantities. Moreover, orders for less than certain minimum tonnages are dealt with by stockholding merchants, who sell nearly one-fifth of all finished steel. All of these measures help to increase productivity, although the saving in production costs is offset for the consumer by the facts that a large proportion of the output is handled by merchants and that the concentration of production involves deliveries over greater distances.

The average iron content of all ores consumed in Britain, based on the 1950 usage of 60 tons of home ore to 40 tons of imported ore, is about 40 per cent compared with about 50 per cent in America. The use of more of the richer imported ores would obviously increase plant, fuel and labour productivities, and steps to achieve this are already being taken. Much remains to be done in ore treatment and beneficiation, both for imported and home ore, although Britain has been at least as progressive as America in this field.

American coking coal is on the average of better quality than British. British blast furnaces operate nearer to the minimum coke consumption rate than American, but there is still room for improvement in the size distribution and bulk density of British coke.

For open hearth and mill furnaces, America has the enormous advantage of abundant reserves of cheap oil and natural gas, which are piped to most parts of the country. The effect of these rich fuels on productivity is shown by the fact that about one-quarter of British open hearth steel production has been converted within the past five years from producer gas to oil firing with an increase of about 10 per cent in furnace outputs. In British soaking pits and reheating furnaces there is considerable scope for improvement in fuel consumption rates. Because richer fuels are plentiful, the works in the South and West of the U.S. do not conserve blast furnace and coke oven gases as British works have to do.

American steelworks plant is driven at high rates. To a large extent this is attributable to the purity of raw materials and fuel, to size of plant units, and to other characteristics peculiar to the American industry. But even after allowing for these, American steelworkers are still able to get 10 per cent to 20 per cent more out of each unit of plant than we do in Britain. In blast furnaces this is accomplished with some increase of coke consumption and in open hearth furnaces with a reduction in roof life. The rolling mills, however, seem to take fast driving with little if any increase in shut-down or maintenance costs.

American manning per unit of plant is generally lower than in Britain, despite higher outputs. Mechanical aids and handling equipment are used wherever practicable. The difference in manning rates is particularly noticeable for steel furnace maintenance where the greater working space provided in melting shop layouts and the provision of many effective mechanical aids result in a considerable reduction in plant downtime.

Research inside the American steel industry is on a relatively small scale, owing perhaps to the comparatively simple metallurgical problems in that country. Ferrous metallurgical research in America as a whole is on an extensive scale, and receives considerable financial assistance from the Government and from the using industries. Co-operative research in Britain has been found to be an efficient way of increasing the technical strength of our industry, and is on a much larger scale than in the U.S.

The cost of making iron and steel in Britain remains low by international standards. It can, however, only be kept so by continuous modernisation and the most effective utilisation of plant. Capital development since the war, together

Continued on p. 222.

D.C. Motor with Split Poles

By V. I. SEREBRYER. (From *Elektrichestvo*, No. 10, 1951, pp. 30-34, 8 illustrations.)

The author carries out a general investigation of the d.c. machine with split poles. Such a machine has twice the number of pole cores and brush sets of an ardinary d.c. machine. Of these, each set of poles can be separately excited, one set of brushes receiving the supply voltage and the other forming part of an internal circuit which may include a separate resistance and parts of the pole windings. The investigation is divided into an analysis, oscillographic records of the starting process, and plots of experimental characteristics taken on a test rig with a machine of this kind operating as a motor. The analysis is based on the conception of the electro-mechanical rotating transformer. The oscillographic records reveal favourable starting properties. Families of curves lead to recommended circuits for industrial applications. Such applications can be numerous wherever starting without a special resistance and a wide range of speed control by manipulation of field excitation alone are desirable.

THE ordinary d.c. motor is usually started either by means of a starting resistance, or by means of a suitable motor-generator set. Speed control is carried out by variation of field excitation. A modification of the motor is investigated which, at constant armature voltage, allows a d.c. motor to be started without a starting resistance and to be capable of speed control over a wider range than is normally possible by field variation alone, though a still wider range is attained by an additional resistance in one of the armature circuits.

This modification consists in the introduction of split poles, which differ from the poles of an ordinary motor in that they each have two independent pole cores; there is twice the number of brush sets compared with the ordinary motor.

In the self-excited armature of an electro-mechanical transformer (Metadyne) freely rotating at uniform speed, the driving and braking torques are expressed as follows:

$$M_m = C_{am}\,\Phi_{ac}\,I_{1a} = (C_a\,W_a\,I_{2a})\,I_{1a} = CI_{1a}\,I_{2a} \qquad (1)$$

$$M_g = C_{ag}\,\Phi_{ap}\,I_{1a} = (C_a\,W_a\,I_{1a})\,I_{2a} = CI_{1a}\,I_{2a} \qquad (2)$$

and the resulting torque vanishes

$$M = M_m - M_g = 0 \qquad (3)$$

Φ_{ac}; Φ_{ap} = the cross and parallel magnetic fluxes excited by the armature.
I_{1a}; I_{2a} = primary (in parallel circuit) and secondary (in cross circuit) armature currents.
C_{am}; C_{ag}; C_a; C = armature constants.
W_a = number of turns of armature winding.

If the field m.m.f., W_p, I_{fp}, of the parallel poles is added to the parallel m.m.f., $W_a\,I_{1a}$, of the armature, the braking (generator) torque will be increased, and the machine becomes a generator. Conversely, if the field m.m.f., $W_c\,I_{fc}$, of the cross poles is added to the cross m.m.f., $W_a\,I_{2a}$, of the armature, the driving (motor) torque is increased, and a motor is obtained. Finally, if the two field m.m.f.'s of the parallel and the cross poles are added to both the parallel and the cross m.m.f. of the armature, a motor is obtained with a very large range of speed variation, because such a machine will have three field windings—the cross armature winding and the two independent windings of the parallel and the cross poles. In this way we arrive at a motor with two separately controlled windings of the parallel and the cross poles, Fig. 2, and, correspondingly, with two independent magnetic fluxes—the parallel and the cross, namely:

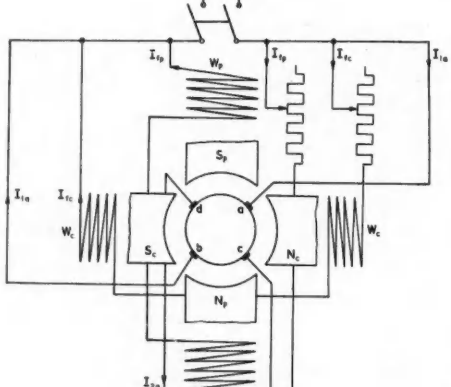


Fig. 1. **Diagram of motor with split poles and separate control of each field winding.**

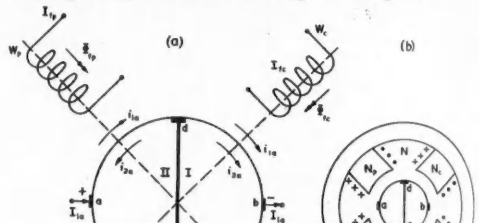


Fig. 2. **a—Distribution of armature currents among quadrants.**
b—Positioning of pole cores and brush sets.

$$\Phi_p = \Phi_{ap} + \Phi_{fp} = C_a\,W_a\,I_{1a} + C_{fp}\,W_p\,I_{fp} \qquad (4)$$

$$\Phi_c = \Phi_{ac} + \Phi_{fc} = C_a\,W_a\,I_{2a} + C_{fc}\,W_c\,I_{fc} \qquad (5)$$

where Φ_p; Φ_c = parallel and cross total magnetic fluxes of motor.
Φ_{fp}; Φ_{fc} = parallel and cross magnetic fluxes of parallel and cross poles.
W_p; W_c = number of turns of parallel and cross pole windings.
I_{fp}; I_{fc} = exciting currents in the windings of the parallel and cross poles.
C_{fp}; C_{fc} = constants of parallel and cross pole windings.

The characteristics of such a motor are expressed by the following set of equations:

$$I_{1a} = \frac{U_1 - E_1}{R_{1a}}\ \text{[amp.]} \qquad (6)$$

$$E_1 = C_1\,n\,\Phi_c\ \text{[volt]} \qquad (7)$$

$$I_{2a} = \frac{E_2}{R_2}\ \text{[amp.]} \qquad (8)$$

$$E_2 = C_2\,n\,\Phi_p\ \text{[volt]} \qquad (9)$$

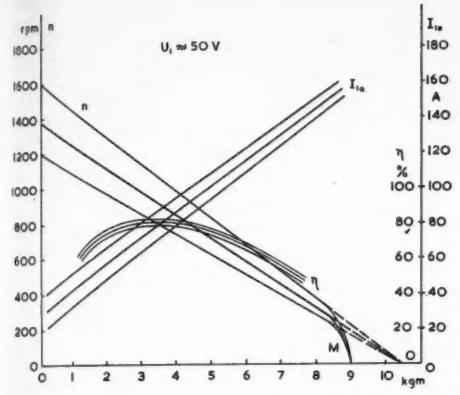


Fig. 3. **Speed of armature n, primary armature current I_{1a} and efficiency η of motor in relation to its resultant torque M.**

$$M = C_m \Phi_c (I_{1a} + I_{2a}) + C_g \Phi_p (I_{1a} - I_{2a}) \text{ [kgm]} \quad (10)$$

$$n = [U_1 - R_{1a} I_{1a}]/[K_m \Phi_c (1 + I_{2a}/I_{1a}) + K_g \Phi_p (1 - I_{2a}/I_{1a})] \text{ [rpm]} \quad .. \quad (11)$$

$$\eta = [U_1 (I_{1a} + I_{fp} + I_{fc}) - (R_{1a} I_{1a}^2 + R_2 I_{2a}^2 + R_{fp} I_{fp}^2 + R_{fc} I_{fc}^2 + P_0)]/[U_1 (I_{1a} + I_{fc} + I_{fp})] \quad (12)$$

where

U_1 = voltage applied to parallel brushes a — b (Figs. 1, 2);
E_1; E_2 = e.m.f. in parallel and cross armature circuits, due to rotation;
n = rpm of armature;
η = efficiency of motor;
P_0 = total iron and friction losses;
R_{1a}; R_{2a}; R_{fp}; R_{fc} = resistances of circuits containing respective windings;
C_1; C_2; K_m; K_g = constants of motor;
$R_2 = R_{2a} + R$; and
R = external resistance in armature circuit.

The properties of the new machine were experimentally investigated. An ordinary two-pole d.c. machine was modified into a split pole motor in accordance with Figs. 1 and 2. The armature remained unaltered; the two pole cores were replaced by four, and two more sets of brushes (c — d, Fig. 2) were added. Oscillographic records were taken of the starting process. Characteristics *experimentally* obtained are given in Figs. 3 to 5.

Oscillographic records have shown that:

(1) In direct starting ($R = 0$) the primary starting current I_{1a} has a transient peak not exceeding three times the rated current, and the drop of current beyond the transient peak is rapid (about 1 second).
(2) The secondary armature current I_{2a} rises quickly and assists the sharp drop of I_{1a}. This process is the fundamental reason why starting without an external resistance is possible.
(3) The motor speed rises exceptionally smoothly.

The characteristics of the motor have the following properties:

(1) The d.c. motor with split poles can be started without a starting resistance. In point of fact, during starting, the brushes c and d are short-circuited; the resistance R in this circuit (Fig. 1) is used for speed control only.
(2) The motor has a smooth acceleration.
(3) The motor is characterised by a very large range of speed control, owing to its three exciting windings W_p, W_c, and W_a. The following considerations will explain these conclusions.

(a) With an increase of the current I_{fc} (when I_{fp} and R_2 are constant) the speed of the motor rises until

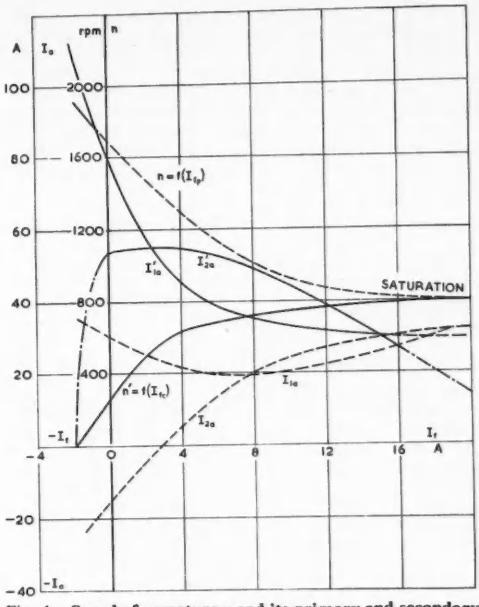


Fig. 4. **Speed of armature n and its primary and secondary currents, I_{1a} and I_{2a}, in relation to the separate currents I_{fp} and I_{fc} in the field windings W_p and W_c for a motor in the circuit of Fig. 1 at $R = 0$.**
Full lines show n', I_{1a}', and I_{2a}', in relation to I_{fc} at a constant I_{fp}
Broken lines show n, I_{1a} and I_{2a} as functions of I_{fp} at a constant I_{fc}.

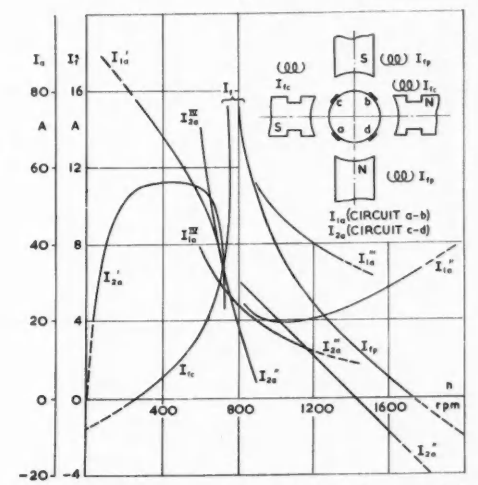


Fig. 5. **Armature currents I_{1a} and I_{2a} and pole winding currents I_{fc} and I_{fp} in relation to the armature speed n for the circuit of Fig. 1.**
Superscripts (′) to (IV) correspond to four families of curves explained in text.

the cross circuit becomes saturated (curve $n = f(I_{fc})$, Figs. 4 and 5). This relation is explained in the theory of the electro-mechanical transformer, where it is found that an increase in the current of the controlling winding W_p weakens the secondary armature current I_{2a}, and thereby has a braking effect. In the motor under investigation, the resulting motive torque increases with a fall in the current I_{2a}. This increase in the motive torque, while the braking torque remains

constant, causes an increase in the rpm of the armature.

(b) With an increase in the current I_{fp} (at constant I_{fc} and R_2) the speed of the motor falls until the parallel circuit is saturated (curve $n = f(I_{fp})$, Figs. 4 and 5). This phenomenon is explained in the theory of the electro-mechanical amplifier, where it is found that an increase in the exciting current of the longitudinal pole winding W_p strengthens, as stated before, the secondary armature current I_{2a}. This causes a fall in the rpm of the armature.

(c) With an increase in R (Fig. 1) at constant I_{fp} and I_{fc}, the motor speed rises (Fig. 5), which is caused by a fall in the secondary armature current I_{2a}.

(d) In this motor it is enough to interrupt the cross armature circuit ($c - d$) and suitably to adjust the pole winding currents in order to get ordinary characteristics.

The graph of I_{2a} as a function of I_{fc} in Fig. 4 can be divided into four zones. Between $I_{fc} = -2$ A and $I_{fc} = 0$ the graph shows that, when the exciting circuit of the cross poles is interrupted, the cross magnetic flux, eq. (5) can only be induced by the m.m.f. of the cross armature circuit $W_a I_{2a}$, and this flux can therefore be controlled by the current I_{fp}. This follows from eqs. (4), (8) and (9).

When I_{fc} is between the values of 0 and 4·5 A the current I_{2a} does not change in spite of the increase in I_{fc} and of a speeding-up of the armature. This is explained by the rise in the e.m.f. $E_1 = C_1 n \Phi_c$ with higher speed, and hence a fall in the current $I_{1a} = \frac{U_1 - E_1}{R_1} I$, which, with I_{fp} = const., keeps the current I_{2a} unchanged. The whole chain of relations is observed in the starting operation; current I_{2a} first rises on account of the flux Φ_c, then stabilises at a speed of 250-300 rpm and remains constant during the starting period, although the current I_{1a} falls sharply. This constitutes a particularly valuable advantage of the motor. It is the presence of the current I_{2a} which allows starting without an external resistance, ensures a smooth acceleration and, what is most important, permits low-speed operation to be attained solely by variation of currents I_{fc} and I_{fp}, denied to the ordinary motor.

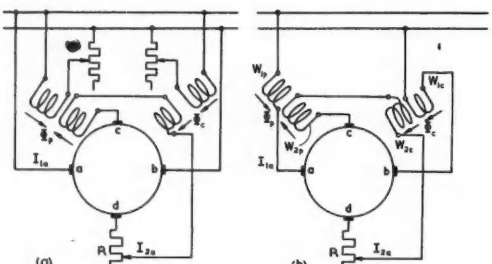


Fig. 6. **Two circuit diagrams for the windings of the motor.**
a—Shunt excitation
b—Series excitation.

In the range between $I_{fc} = 4{\cdot}5$ A to $I_{fc} = 16$ A, the cross magnetic circuit of the motor begins to be saturated, and a rise in the current I_{fp} causes the current I_{2a} to fall.

In the fourth range, where I_{fc} exceeds 16 A, a full saturation of the cross magnetic circuit takes place. A further rise in the current I_{fc}, although it causes a fall of the current I_{2a}, no longer influences the speed of the motor.

The curve of I_{2a} *vs.* I_{fp} in Fig. 4 shows that it is entirely possible to make the relation between I_{2a} and I_{fp} automatically controlled.

Fig. 5 shows several groups of characteristics, taken on a test rig, of the motor with I_{fc} or I_{fp} kept constant. The first, (superscript $'$) is a set of curves of I_{1a}, I_{2a} and n as functions of I_{fc} at a constant I_{fp}. The second, (superscript $''$) is a set of curves giving the same quantities as a function of I_{fp} at I_{fc} = constant. The third family of characteristics (superscript $'''$) gives I_{1a} and n as functions of I_{2a} whilst I_{fc} is maintained at a constant value. This family represents the following test set-up. The winding W_p of the parallel poles is connected in series with the cross armature circuit through the brush set $c - d$. The fourth group, (superscript IV) consists of I_{1a}, I_{2a} and n curves as functions of the total resistance R_2 of the cross armature circuit, whilst the two currents I_{fc} and I_{fp} in both sets of pole windings are kept constant.

These results prove that, by utilising all three means of control (R, W_p and W_c), we can obtain a motor possessing extremely flexible characteristics. In particular, several windings of the motor can be connected in accordance with one of the diagrams of Fig. 6 to obtain the general properties of either a series or a shunt motor.

It can be concluded from these investigations that the d.c. motor with split poles can find many applications in paper mills, textile factories and metal-working industries, as well as in electric traction, where operation with frequent stops is required.

A New Micro-Bending Test Method.

By N. MIRONOFF. (From *Revue de la Soudure, Belgium*, Vol. 7, No. 4, 1951, pp. 214-232, 31 illustrations.)

IN order to ensure better reproducibility of the results of micro-bending tests, the author has designed an apparatus with adjustable chucks movable in specified directions so that the angle of bending as well as the length of the zone of deformation can be held strictly constant. The thickness of the test piece may vary from 0·2 to 4 mm (0·008 to 0·16 in.) and should be uniform to within 3 or 4 per cent over the zone of deformation. The width, limited to 12 mm ($\frac{1}{2}$ in.) by the apparatus, has no influence on test results, apart from the effects of inhomogeneity of the test material. The length must be at least 8 to 10 mm for specimens up to 1 mm thickness and 15 mm for thicker specimens. However, on longer specimens, tests can be taken at 5 mm (13/64 in.) intervals. The specimens may be sawcut, but should be finished by filing to eliminate the working stresses.

The test piece presents an "encastré" micro-beam bent by uniform end couples without mandril or other supports. One end is kept stationary, the other rotated about a centre so chosen that the length L of the neutral fibre within the zone of deformation bears a constant relationship to the thickness d of the specimen throughout the test. The ratio L/d represents the "intensity," the maximum bending angle A the "amplitude" of a "unit" test deformation, whilst $A \times N$ (N = number of reversals to fracture) gives the total test deformation. Intensity and amplitude are strictly proportional in their effects as shown by experiment. If L/d is kept constant and A altered, N is found to be proportional to $A - A'$, where A' is a coefficient of the test material and its metallurgical state only, and independent of the geometry of the test apparatus. It varies between 20 and 40 deg. for the usual industrial metals. On the other hand, the calculated maximum extension of the extreme fibre for a given constant amplitude angle A is found experimentally to be inversely proportional to N. It is thus possible to increase the sensitivity of the reverse-bending test by decreasing the angle of bending.

Experimental results obtained with this apparatus scatter by less than 6 per cent in repeated tests on

homogeneous materials. The test is sensitive enough to demonstrate the effects of anisotropy of single grains in a coarse-grained aluminium test specimen with a thickness of one grain size (0·5 mm). According to the orientation of the grain in the zone of deformation, N varies by as much as 62 per cent. Tensile tests on mono-crystals are known to give variations of up to 68 per cent. When the width of such a specimen is halved and each half tested separately, N is identical for the two halves of one original grain. The extent of scatter of the results thus gives a certain indication of the grain size in the specimen.

The new testing method is especially revealing in connection with the thermal effects of welds, since consecutive tests can be taken on very small regions very close together in one test bar. Whilst the usual hardness tests only show variations of strength across the weld and parent metal, the micro-bending tests determine the changes in ductility. Although a direct numerical relationship between N and the ductility would depend on the work-hardenability of the test material, it can roughly be said that the ductility varies similarly to N. Hence, an investigation of the weld

(*Concluded on page 228*)

GERMANY

Optical Determination of the Quality of Metallic Surfaces

By J. Elze and H. Grüss. (From *Metalloberfläche*, Vol. 6, No. 2, February 1952, pp. A17-A23, 12 illustrations.)

The brightness of a metallic surface cannot be defined as the total amount of reflection from the surface, since a mat white surface may reflect more than a metal surface of poor mirror quality. Nor can it be defined as the amount of light reflected at the geometrical mirror angle since the micro-waviness of a surface may dim the "mirror" reflection, even though the surface appears lustrous to the eye. The most convenient definition, therefore, seems to be that of the amount of light reflected within a stray cone of chosen apex angle

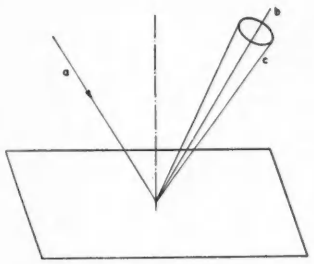


Fig. 1. **Stray reflection within a narrow one.**
(*a*) incident ray ; (*b*) reflected ray (mirror reflection) ; (*c*) stray cone with small apex angle.

about the axis of the geometrically reflected ray (Fig. 1). This apex angle may be chosen arbitrarily, but measurements of the intensity distribution of the reflection from various surfaces suggest an optimum value of about 26 degrees (Fig. 2). Practically the whole amount of reflected light from bright metal surfaces, but only a small portion of the reflection from mat non-metallic surfaces, is contained within that angle ; mat metallic surfaces reflect a fair amount within these limits. However, an instrument for the measurement of brightness should provide a choice of various angles and also allow determination of the geometrically exact mirror reflection without stray effects. A point source of light and entirely plane reflecting surfaces are thus required, since any noticeable curvature will produce astigmatism, and hence stray effects not inherent in the quality of the surface. The effect of polishing grooves, on the other hand, should enter the measurements.

The schematic arrangement of the instrument in the form of an optical bench (Fig. 3) shows the point source of light (1) (a bulb for car headlamps, arranged with its filament along the optical axis) and condenser lens (3), both horizontally and vertically adjustable on a fixed arm of the bench. A second, horizontally rotatable, arm

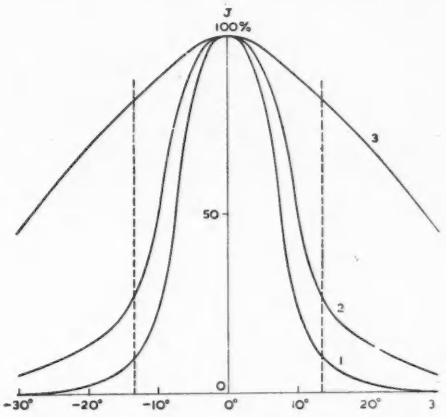


Fig. 2. **Distribution of intensity of reflected light.**
(1) From lustrous metallic surfaces, 70 per cent reflected in narrow cone ;
(2) from rolled aluminium sheet, 16 per cent reflected in narrow cone ; and
(3) from white paper, 4 per cent reflected in narrow cone.

carries a lens (5) of short focal length, a frame (6) for interchangeable diaphragms, and a selenium cell (7). A daylight colour filter (2) ensures a spectral distribution corresponding to that of the human eye. For calibration, the two arms are in line, so that 100 per cent of the light passing through lenses (3) and (5) is taken up by the photocell and produces a galvanometer deflection of 100 units. The test surface is then inserted at the pivot of the bench, so that, if it be a mirror, the total reflection is concentrated by lens (5) as a point image in the diaphragm plane (6). If the diaphragm opening has just the size of the image, then only the geometrical mirror reflection will pass on to the photocell ; if larger diaphragms are used, the photocell will also record the magnitude of the stray reflection limited by the diaphragm opening. The sheet samples (2 in. × 2 in. × 0·04 in. thick) are clamped flat against a rigid frame. The lamp current must be controlled very accurately and is taken from the mains through a voltage-controlled transformer, an iron-hydrogen resistance 50/150 V, 80mA, and a second transformer giving 4 V. A shunt provides fine adjustment, and frequent control calibration is carried out by means of a standard mirror (aluminium evaporated on to glass) with 82·5 per cent reflection. The bench is initially

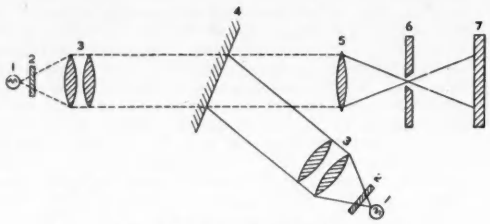


Fig. 3. Schematic arrangement of instrument.
(1) Lamp; (2) filter; (3) condenser; (4) surface of specimen; (5) lens; (6) diaphragm; (7) photocell. Dotted lines indicate optical path for calibration.

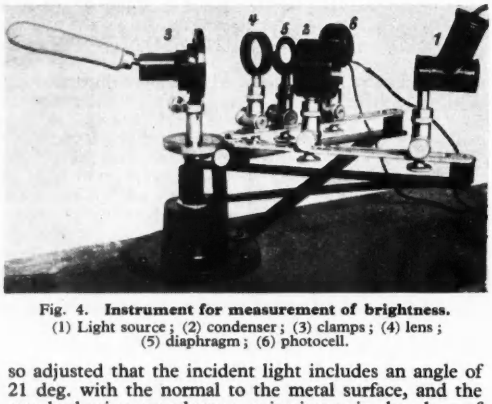


Fig. 4. Instrument for measurement of brightness.
(1) Light source; (2) condenser; (3) clamps; (4) lens; (5) diaphragm; (6) photocell.

so adjusted that the incident light includes an angle of 21 deg. with the normal to the metal surface, and the standard mirror produces a point image in the plane of the diaphragm, i.e., maximum galvanometer deflection with a small diaphragm opening. After removal of this diaphragm, the galvanometer then shows a deflection of 82·5 units. When the test sample is inserted, the "mirror" reflection is first measured with a diaphragm of 0·1 in. dia. opening, and the mirror plus stray reflection then obtained with diaphragms of 0·5 and 1 in. diameter or without any diaphragm. The 1-in. diaphragm passes stray reflection within a cone of ± 7 degrees. Elliptical diaphragms indicate position and magnitude of the maximum and minimum stray reflection due to astigmatism produced by polishing grooves. Non-metallic surfaces and initial oxide or other corrosion layers are characterised by high intensities at wide stray angles, and the instrument is sensitive enough to give quantitative results for such surfaces. Results are reproducible to within 1 per cent; a reliable measurement of the "mirror" reflection, however, requires especially careful adjustment.

APPLICATIONS.

(a) The stray angle of the reflected light increases if the polishing grooves of a specimen are normal to the plane of the incident and reflected ray, and is smaller if the grooves are parallel with this plane. For a stray cone of given apex angle, the difference in amount of reflection may be 3 to 4 per cent, i.e., measurable with the instrument.

(b) The surface of several sheets of pure aluminium (99·99 per cent), ground or ground and polished, was improved by two different dip processes I and II, and as a comparison, polished Al-alloy sheet was similarly treated. The measurements (Table I) show that process II is superior for pure aluminium, process I for Al-alloy, and that a treatment I followed by II appreciably increases the surface quality in all cases. Process I, in fact, reduces the mirror effect R_S of the ground and polished Al-sheet, process II increases it. This indicates that process II exerts a good smoothing action, while the higher increase in stray reflection R_N due to process I shows that I merely imparts a higher brightness. Visual comparison confirms that an increase in R_N is experienced as an improvement in brightness, an increase in R_S as an improvement in surface smoothness.

TABLE I. INCREASE IN STRAY REFLECTION (ΔR_N) AND INCREASE IN "MIRROR" REFLECTION (ΔR_S) DUE TO CHEMICAL POLISHING OF ALUMINIUM SHEET BY TWO DIFFERENT PROCESSES.

Process	99·99% Al-sheet ground		99·99% Al-sheet ground and mech. polished		Al-alloy sheet ground	
	ΔR_N	ΔR_S	ΔR_N	ΔR_S	ΔR_N	ΔR_S
I	44	3	21	−5	47	35
II	32	4	20	25	24	4
I + II	47	44	—	—	49	43

(c) A difference between better smoothing action (R_N-increase) and mere increase in brightness (R_S-increase) was observed on copper sheets, nickel-plated in two different baths. The directional effect of the polishing grooves in the copper base, still observed after nickel-plating in one bath but disappearing after plating in the other bath, confirmed the original, non-directional differences found between R_N- and R_S-improvements. Micro-photographs of varnish replicas also confirmed the measured phenomena. It is noteworthy that the slight effect of polishing grooves can be clearly measured and that, in contrast to other methods, the brightness measurements give integral values over the whole metal surface.

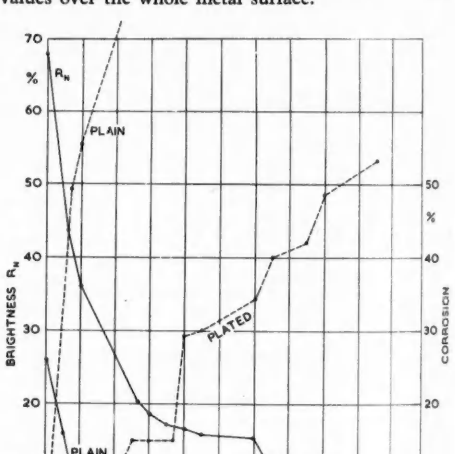


Fig. 5. Corrosion measurements on ground deep-drawing steel, plain and nickel-plated, in an industrial atmosphere.
Full lines: Brightness measurements.
Dotted lines: Visual estimation of corrosion layer.

(d) The onset of slow corrosion can be measured objectively with the instrument and can be discovered by a decrease in brightness (R_N) long before it can be estimated visually. The loss in brightness of nickel-plated deep-drawing steel (Fig. 5) is discovered within one day, while a noticeable corrosion layer becomes visible only after about 5 days.

Phosphate Coatings as Lubricants in the Severe Cold Forming of Metals

By S. SPRING and L. K. SCHUSTER. (From *Iron and Steel Engineer*, Vol. 29, No. 5, May, 1952, pp. 64-71, 3 illustrations.)

THE phosphatising of metals to facilitate cold forming operations* is accomplished by immersion of the metal being phosphated in a dilute phosphoric acid solution of another phosphate. Steel, for example, is prepared for forming by immersion for 2-7 minutes in a hot solution of zinc phosphate in phosphoric acid, followed by rinsing and an immersion in an oil or an emulsion lubricant.

Phosphate coatings now make operations practical which were hitherto considered uneconomical. The advantages of phosphatising can be summarized as follows:—(a) increased die life, (b) higher drawing speeds, (c) greater single reductions, (d) elimination of some annealing operations, (e) prevention of scoring, galling and pick-up, and (f) improved corrosion resistance. The process is applicable to plain carbon steel and low alloy steels, aluminium and its alloys, and zinc and zinc alloys. Phosphatising cannot be applied to ferrous metals of austenitic structure such as stainless steel.

For the preparation of the phosphatising bath, the usual method is to have two solutions, one of which is used to replenish the bath and maintain it at the proper concentration. Generally, the bath is of the order of a 2 per cent solution of the concentrate dissolved in water. The tank can be made of mild steel. The greater portion of the water is put into the tank and heated to approximately the correct temperature of 160-180° F before the concentrates are poured in. Heating is by means of steam coils, preferably of stainless steel, arranged along the side of the tank. The insoluble material or sludge which settles at the bottom of the tank is removed periodically, for instance, about once a month.

The pickling action of the acid on the steel has the effect of reducing the acidity in the layer of solution next to the steel surface. Provided that the initial reduction in acidity takes place gradually, so as to avoid precipitation of the zinc phosphate, the latter will deposit on the steel surface, particularly on receptive portions such as grains of ferric carbide, particles of pickling smut, electrically active centres due to local galvanic couples, rust and non-metallic deposits, etc. The process is accelerated once some of the zinc phosphate molecules become attached to these receptive centres. The pickled surface gives better adherence than an unpickled surface, because it provides a larger surface area to which the basic layer of zinc phosphate can attach itself. However, an excessive amount of pickling smut or burnt drawing lubricant should be avoided, since this would result in loosely attached centres. Adherence is also improved by adequate rinsing before phosphatising, whether the metal is treated in an acid solution or in an alkaline cleaner.

The phosphatising results in the formation of a crystalline deposit which is strongly attached to the surface. For cold forming work, the crystal size is of little importance. The feathery zinc phosphate crystals deposited on steel, for instance, are intertwined to form a uniform structure, which is not, however, continuous. The coating contains a number of pores, of which about 1½ per cent go through to the steel surface. The porous nature of the phosphate coating permits a quantity of organic lubricant to be absorbed in this porous matrix. This is released as the metal goes through the die, thus providing lubrication where it is most needed.

In addition to the separating action provided by a phosphate coating, a supplementary lubricant is required to reduce rubbing friction and for this purpose emulsion, soap or oily lubricants containing fatty acid are used. The chemical rinsing of the phosphate coating before immersion in the organic lubricant makes the coating more reactive so that a rapid chemical reaction takes place between the zinc of the zinc phosphate and the fatty acid residues in the organic lubricant, resulting in the formation of soaps and partial soaps. This frequently gives a substantial improvement in the overall performance of the process.

During its passage through the die, the phosphate coating is converted into an amorphous or glassy condition, and provided its initial thickness is sufficient, it is possible in many cases to draw metal a second or third time with this coating. The glass-like phosphate coating can be subsequently removed by a mild pickling operation or an alkali treatment to yield the basic metal surface, or it may be left on the surface after superficial degreasing in order to contribute to corrosion resistance and give a glossy surface.

Although reasonably good results can be obtained by low-pressure spraying of the solutions, it is recommended for most severe cold forming operations to use the bath as an immersion bath, since the heaviest and most adherent coatings are obtained in this way. In general, it has been found possible to use lubricants in conjunction with phosphate coatings at much lower concentrations than were hitherto possible with other types of lubrication, and this reduction in the cost of lubricant compensates to some extent for the cost of phosphatising the surface.

Good coatings are obtained on plain carbon steels and the lower alloys. In general, the process is not applicable to austenitic steels or steels with a chromium content higher than 10 per cent. Intermediate alloys with 3 to 8 per cent chromium can be processed. The coatings are relatively thinner, but this can be compensated for by increasing the time of immersion in the bath or by using special lubricants. Performance in these cases is still far superior to that which could be obtained by the use of the lubricant alone.

REDUCED COEFFICIENTS OF FRICTION

In the cold working of metals, lubrication becomes more of a problem with increased unit pressures necessary to perform a specific press operation. Therefore, any measure which reduces friction will facilitate the cold working process. It has been found that phosphatised surfaces give considerably lower coefficients than uncoated surfaces. Typical results are given in Table I.

TABLE I.

Lubricant: diluted fat-soap emulsion applied by soaking at 160° F for one hour.

Unit pressure psi	Apparent coefficients of friction			
	Uncoated	Zinc phosphate	Manganese phosphate	Cadmium phosphate
10,000	0·108	0·013	0·085	0·034
50,000	0·068	0·032	0·070	0·069
100,000	0·057	0·042	0·059	0·055
200,000	0·070	0·043	0·066	0·055

Equally favourable results are obtained with phosphatised surfaces when other types of lubricants are used, such as pigmented fat-soap paste (chalk), or solid calcium stearite.

The effectiveness of the phosphatising process is

*The first patent for this process was granted to F. Singer, in Germany, in 1934.

also indicated by the amount of lubricant absorbed with different immersion times and temperatures. Results are shown in Table II.

TABLE II.

Lubricant : 1 per cent sodium stearate solution.
Surface : Phosphatised.

Immersion time	Temperature °F	Weight of lubricant film, gr/sq ft
Few seconds	65	0·070
" "	160	0·090
One hour	65	0·150
" "	160	0·740

It is of interest to note the reduction in cross-sectional area obtained in drawing carbon steel using two types of lubricants in combination with a phosphatised surface, applying a unit pressure of 200,000 psi :—With lubricant " A " (diluted fat-soap emulsion, 160° F, one hour), the reduction is 52·5 per cent. With lubricant " B " (solid calcium stearite), a reduction in area of 47·0 per cent is obtained.

STAMPINGS

In stamping work, the unit stress in the tool averages 5000-10,000 psi. Wet lubricants of the fat-soap emulsion type, either unpigmented or pigmented, are usually applied directly at the press. For more difficult stampings with stresses concentrated in particular areas, dry soap or wax films are suitable. However, the application of a phosphate coating may be necessary in some instances, as illustrated in the following example. A tub for an automatic washing machine was to be formed from a blank in four or five operations on one press. On the second redraw die (sleeve die) severe pick-up occurred, necessitating stoning of the die after each three or four pieces, and the use of a dry soap film did not give sufficient improvement. By phosphatising the blanks, the pick-up and consequent stoning operations were completely eliminated and production was increased by more than 100 per cent.

It should be noted that the press must be adjusted to the phosphate lubricant system to avoid breakage and too shallow draws. Frequently, the blank holder pressure must be decreased.

WIRE DRAWING

Comparative tests were carried out with phosphate-coated wire and lime-coated wire (2 lime dips) using a dry soap-lime lubricant. The coils (400 lb. each) were rolled from a single ingot of steel, containing 0·67 C, 0·70 Mn, 0·013 P, 0·030 S and 0·20 Si. The coils were drawn with a speed of 1800 fpm through four die holes (tungsten carbide dies) with about 30 per cent reduction per pass and a total reduction of about 75 per cent. The results obtained are given in Table III. This table also gives the corrosion resistance of the final drawn wire, the amount of rust having been determined after exposing the wire to salt spray for 24 hours.

TABLE III.

Treatment	Tensile strength, psi	Elongation, per cent	Reduction in area, per cent	Rust gr/sq ft
Lime coat	229,570	5·25	48·15	2·52
Phosphate	226,850	5·5	49·3	1·42

The die life was approximately 2-3 times greater in the case of the phosphatised wire than for the lime coated wire.

To determine the power consumption and the die pull with the two lubrication methods, comparative tests were made on a drawing machine equipped with a kilowatt-meter and a dynamometer. The same wire as previously was drawn to 0·183 in. diameter, patented and then drawn through three die holes on a single drawblock. Typical results obtained at a drawing speed of 350 fpm are shown in Table IV.

The table shows that for the first two dies, the die pulls for the phosphatised wire are about 20 per cent lower than those for lime-coated wire. Further tests with dry soap-lime lubricant on phosphatised wire were made at speeds up to 745 fpm and showed efficiency values as high as 77 per cent, the efficiency being defined as the ratio of the theoretical to the actual die pull. The theoretical die pull, i.e., the force to overcome internal friction, was calculated from the mean tensile strength before and after reduction.

The advantages of phosphatising cannot be utilised completely when drawing round wire, but an excellent application of phosphatising is obtained when drawing odd-shaped wire, where pick-up frequently occurs.

In wet wire drawing of finer wire, which is performed at high speeds and with excellent cooling by the dilute lubricant which floods the die holes, the application of phosphatising is particularly advantageous. Its use results in : (a) an increase in speed of 40 per cent or more, (b) 2-5 times higher die life, (c) decreased lubricant consumption, (d) improved corrosion resistance of the wire, (e) smoother finish and excellent appearance, and (f) a cleaner mill.

TABLE IV.

Treatment	Diameter before and after, in.	Per cent reduction	Die pull, lb		Frictional load, lb	Unit stress psi	Power kW
			Theoretical	Actual			
lime	0·183–0·153	29	1058	1543	485	195,000	15·83
phos.	" "	"	1035	1438	393	182,100	15·25
lime	0·153–0·129	29·4	840	1155	315	217,000	12·69
phos.	" "	"	849	1097	248	206,500	12·36
lime	0·129–0·109	28·5	652	875	223	233,600	10·13
phos.	" "	"	655	873	218	233,300	10·25

In the manufacture of screws and bolts, which are produced from pre-drawn rods by cutting and upsetting, phosphatising eliminates pick-up and scoring, and provides a high die life and an excellent finish.

TUBE DRAWING

In the tube drawing industry, phosphatising has become an indispensable feature. It permits the drawing speed to be increased considerably, sometimes several times, makes higher single reductions possible, eliminates pick-up to a considerable extent, and even minimises annealing operations. The tubes thus produced have a smooth finish and a good corrosion resistance, and there is a considerable decrease in scrap.

DEEP DRAWING

The advantages of phosphatising in this field are the same as in tube drawing. In the manufacture of hollow bodies, such as gas bottles, fire extinguishers, ordnance items, etc., it allows substantially greater reductions, and annealing operations can be reduced considerably. For example, a steel cartridge case, finished conventionally from a cup in four draws and annealing after each draw, using a dry soap film, can be made with the aid of a phosphate coating in four draws without any intermediate anneal and with a total reduction of more than 80 per cent in cross-sectional area. Although this may not be completely achievable under mass-production conditions, the benefits are considerable. Furthermore, phosphatising completely eliminates the difficulties which are frequently ex-

perienced when a dry soap film is exposed to high humidity at elevated temperatures.

COLD EXTRUSION OF STEEL

As cold extrusion subjects the metal to compression, the tensile strength value is meaningless and in theory the metal is extremely plastic, permitting reduction in cross-sectional area of 85 per cent or even more, per single press operation. However, owing to the extremely high stresses encountered, the practical limits of cold extrusion are set by tool strength, friction and press equipment.

In the cold working of low-carbon steel by extrusion, pressures of 250,000 psi and higher are obtained for forward extrusions, i.e., where the steel is forced to move in the same direction as the punch, and 300,000 psi or higher for backward extrusions, such as the piercing of a hole in a billet under compression. Cold extrusion may replace more and more the conventional method of hot forging and machining for the manufacture of heavy-walled hollow bodies, such as projectiles, rocket-heads, etc. Starting from billets sawn or cut off hot-rolled bars, and cupping by backward extrusion, at least 50 per cent of the metal is saved. The piece can be finished by conventional methods such as drawing, or finished to final length by extrusion. In general, it may be said that one extrusion operation replaces two drawing operations.

Cold extrusion is of importance even for hollow bodies such as cartridge cases. The yield of the ingot to discs is about 35 per cent, and the yield of the ingot to bar stock is about 68-70 per cent.

RUSSIA

The Effect of the Structure of Cable Insulating Paper on its Dielectric Strength

By V. N. YOFFE. (From *Elektrichestvo*, No. 11, 1951, pp. 40-43, 5 illustrations.)

A structural model of cable insulating paper is proposed, which takes account of several types of voids between cellulose fibres. This model yields expressions for the different dielectric constants in different directions. Measurements confirm the validity of the new expressions. The improved model of paper structure is important only at low paper densities.

THE calculation of the dielectric constant of impregnated paper insulation is based on a formula which proceeds from the assumption that the capacity of the cellulose is connected in series with the capacity of the impregnating substance :

$$\epsilon_i = \frac{\epsilon_m \epsilon_c}{a\,\epsilon_c + (1 - a)\,\epsilon_m} \quad .. \quad (1)$$

where ϵ_c and ϵ_m are the dielectric constants of cellulose and impregnating substance respectively, and a is the relative porosity of the paper.

Unimpregnated paper simplifies the formula, because $\epsilon_m = \epsilon_{air} = 1$ and $\epsilon_c = 7$. Replacing the relative porosity a by $(1 - k)$, where k is the percentage of paper volume occupied by cellulose, we obtain :

$$\epsilon_u = \frac{7}{(1 - k)\,7 + k} = \frac{7}{7 - 6\,k}$$

The relative volume of cellulose k is related to the specific gravity of paper in accordance with the formula $k = \gamma/\gamma_c$, where γ and γ_c are the specific gravities of paper and of cellulose respectively. Assuming $\gamma_c = 1{\cdot}55$, we obtain $k = \gamma/1{\cdot}55 = 0{\cdot}6458\,\gamma$ and

$$\epsilon_u = \frac{7}{7 - 3{\cdot}87\,\gamma} \quad .. \quad .. \quad (2)$$

Eq. (1) is confirmed by experiment provided the special features due to the manufacture of the paper, such as the pattern of solidification of cellulose are taken into account. Fig. 1 gives the theoretical and experimental values of dielectric constants of cable insulating paper related to its specific gravity. Curve 1 represents eq. (2). Curve 2 is obtained by measurements between mercury electrodes of the dielectric constant of dry paper. Test values exceed theoretical expectations.

The explanation of this discrepancy is that the assumption underlying eq. (2) is the presence of voids exclusively in the form of layers or channels parallel to the surface of the paper, but not at right-angles to this surface. This assumption is adequate for condenser papers having a very small porosity, but does not apply so well to cable papers with relatively large porosity.

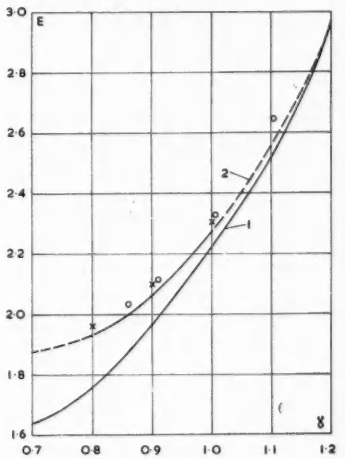


Fig. 1.

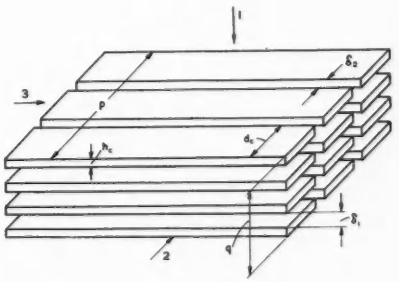


Fig. 2.

Fig. 2 is a pattern of laminae and fibres representing cable insulating paper. This structure is a better model of real paper than the simple pattern of cellulose and air capacities arranged in series. In the following we shall call the direction shown by arrow 1 "normal," that shown by arrow 2 "transverse," and that shown by arrow 3 "longitudinal."

In the normal direction, the capacity C_c of cellulose is arranged in series with capacity C_{a1} of the air enclosed in the voids δ_1. At the same time, capacities C_{a2} of air enclosed in the gaps δ_2 are connected in parallel. In the transverse direction, capacity C_c is linked in series with capacity C_{a2} and in parallel with capacity C_{a1}. Lastly, in the longitudinal direction, capacity C_c is in parallel with capacity C_a of the whole air enclosed in the paper (combining capacity C_{a1} and capacity C_{a2}). From this structural model we obtain expressions relating the dielectric constant in the normal, transverse, and longitudinal directions to the specific gravity of the paper.

Let us consider a cube of unit dimensions. The total thickness of cellulose in the normal direction is q, and in the transverse direction p. The following relations result :

$$q = h_c n_1 \text{ and } p = d_c n_2$$

where h_c and d_c are the thickness and width of a cellulose fibre, and n_1 and n_2 the number of fibres over a unit of length in the normal and transverse directions respectively. The quantity pq equals the total area of cellulose in a unit of area in a plane perpendicular to the direction of the fibres. This quantity is therefore equal to the relative volume k of cellulose in the paper.

Introducing former terms, we obtain

$$p\,q = \frac{1 - a}{1} = k \quad .. \quad .. \quad (3)$$

Since the number of channels in the normal direction is below the number of channels in the transverse direction, it can be said that $q < p$. In the longitudinal direction, capacity C_c is linked in parallel with capacity C_a. Hence,

$$\epsilon_3 = pq\,\epsilon_c + (1 - pq) \quad .. \quad .. \quad (4)$$

Equally, by analogy, the dielectric constants in the two remaining directions are

$$\epsilon_2 = 1 - \frac{k}{p} + \frac{k\,\epsilon_c}{(p - p^2)\,\epsilon_c + p^2} \quad .. \quad (5)$$

$$\epsilon_1 = 1 - p + \frac{p\,\epsilon_c}{\left(1 - \frac{k}{p}\right)\epsilon_c + \frac{k}{p}} \quad .. \quad (6)$$

Replacing k by γ, we obtain the following set of equations for impregnated paper insulation.

$$\epsilon_3' = 0{\cdot}645\,\gamma\,\epsilon_c + (1 - 0{\cdot}645\,\gamma)\,\epsilon_m \quad .. \quad (7)$$

$$\epsilon_1' = (1 - p)\,\epsilon_m + \frac{p^2\,\epsilon_c\,\epsilon_m}{(p - 0{\cdot}645\,\gamma)\,\epsilon_c + 0{\cdot}645\,\gamma\,\epsilon_m} \quad (8)$$

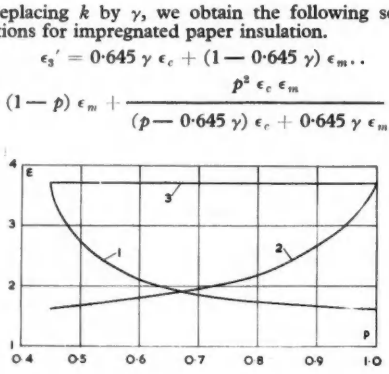


Fig. 3.

$$\epsilon_2' = \left(1 - \frac{0{\cdot}645\,\gamma}{p}\right)\epsilon_m + \frac{0{\cdot}645\,\gamma\,\epsilon_c\,\epsilon_m}{(p - p^2)\,\epsilon_c + p^2\,\epsilon_m} \quad (9)$$

Unimpregnated paper simply requires replacement of ϵ_m by unity.

Figure 3 illustrates the three dielectric constants in relation to the quantity p for a paper of 0·7 gr/cm³. The differences in the dielectric constants in the transverse and longitudinal directions are caused entirely by the presence of channels perpendicular to the surface of the paper. Thus, the ratio of the dielectric constants measured in the transverse and longitudinal directions can serve as a criterion of the specific sectional area of the channels traversing the paper at right-angles to its surface. When $\epsilon_2/\epsilon_3 = \eta = 1$, the capacities C_c and C_a are connected purely in series, and the dielectric constant of the paper is at a minimum. The lower the coefficient η, the higher the dielectric constant of the paper at a given specific gravity.

In practice, the measurement of coefficient η was carried out by measuring the capacity of a disc spirally wound from paper strip cut in the appropriate direction, i.e., either in the transverse or in the longitudinal direction. The disc was placed between flat electrodes, ensuring a good fit between the faces of the disc and the electrodes. The coefficient η is the ratio of the capacities of two discs of identical dimensions wound respectively from transverse and longitudinally cut strips of paper. The author shows that the capactiy of the air contained between the windings is small and, moreover, since it exists in both discs, its influence on the measured ratio is quite negligible.

Cable insulating papers of a specific gravity of 0·8 were found to have a coefficient η within the limits of 0·68 to 0·75. The relation between the coefficient η and the quantity p for a paper of given specific gravity can be obtained in the following manner. Assuming a quantity p, we obtain from eq. (9) the dielectric constant in the transverse direction. The dielectric constant in the longitudinal direction, which is independent of p, is obtained from eq. (7). The ratio of the two quantities ϵ_2 and ϵ_3 gives the coefficient η corresponding to the assumed value of p.

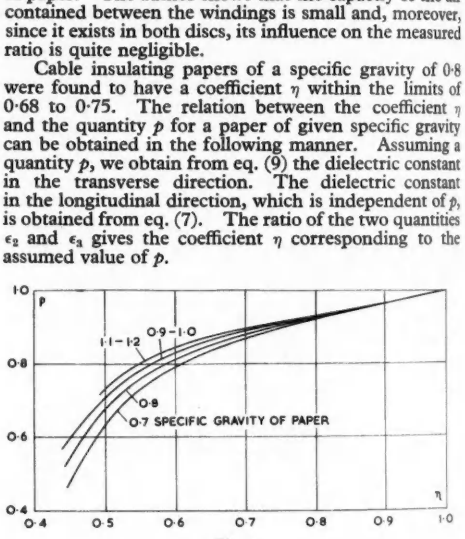


Fig. 4.

In practice, p can change between 1 and k. In Fig. 4 the relation between p and the coefficient η is illustrated for papers of several specific gravities, namely, 0·7, 0·8, 0·9 and 1·0, 1·1 and 1·2. For approximate calculations the quantity p for papers of specific gravity 0·8, 0·9, 1, can be taken as 0·87, 0·95 and 0·98 respectively.

For accurate calculation of the dielectric constant of impregnated paper, the quantity p must be obtained from measurements of the coefficient η evaluated by means of eq. (8) . In Fig. 1, the broken line is the result of applying eq. (8) with the values of p taken from the recommendations of the previous paragraph. Curves (1) and (2) should coincide at the specific gravity of 1·55, which is the specific gravity of cellulose and denotes a complete absence of porosity. In practice, the difference becomes unimportant beyond a specific gravity of 1·1.

The Dynamic Capacity of Roller Bearings

By G. LUNDBERG and A. PALMGREN. (From *Acta Polytechnica*, Mechanical Engineering Series, Vol. 2, No. 4, Issue 96, 1951, 32 pages, 16 illustrations.)

This article sets forth the results of further investigations into the theory of roller bearings, originally published in 1947.* *This theory has been modified in certain respects, and a simplified method has been evolved for the calculation of dynamic capacity and bearing life.*

THE life L (in millions of revolutions) of a bearing application can be determined as a function of the dynamic capacity C of the bearing and the applied load F, by means of the relation

$$L = (C/F)^p \quad .. \quad .. \quad (1)$$

The calculation of C is indicated in Table I. The tests carried out have shown that the following values can be used for the exponent p:—

$p = 3$ for point contact against both rings,
$p = 4$ for line contact against both rings, and
$p = 10/3$ for line contact against one ring and point contact against the other.

The symbols used are as follows (see Fig. 1):— D_a = roll body diameter, d_m = pitch diameter, r_i = raceway radius, R = roll body cross profile radius, i = number of rows of roll bodies, α = contact angle, Z = number of rolling bodies per row, l_a = contact length of roll bodies. For conventional roller bearings,

$l_a = l_r - 1{\cdot}2\, l_r^{0{\cdot}4}$ with grinding relief grooves in the bearing raceways, and

$l_a \sim 0{\cdot}9\, l_r$ .. (l_r = length of rolling body) for bearings without relief and considering end radii.

Units used:—forces in kilogrammes, linear dimensions in millimetres.

From the experiments which have been carried out, it follows that the edge loading coefficient λ can vary between 0·4 and unity. For thrust bearings, the factor η accounting for uneven load distribution depends on the contact angle α and can be determined from

$$\eta = 1 - k \sin \alpha \quad .. \quad .. \quad (2)$$

The values of λ are given in Table II. This table includes values for a correction factor ν which will be used later.

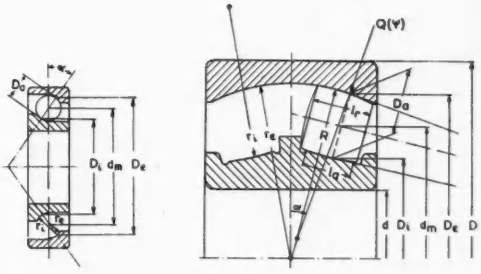


Fig. 1

The resultant dynamic capacity is then determined by means of the following formulae.

For roller bearings with line contact against both rings:

$$C = C_{ll} = C_{il}/[1 + (C_{il}/C_{el})^{9/2}]^{2/9} \quad .. \quad (3)$$

$$L = (C/F)^4 \quad .. \quad .. \quad .. \quad .. \quad (3')$$

For roller bearings with point contact against both rings:

$$C = C_{pp} = C_{ip}/[1 + (C_{ip}/C_{ep})^{10/3}]^{0{\cdot}3} \quad .. \quad (4)$$

$$L = (C/F)^3 \quad .. \quad .. \quad .. \quad .. \quad (4')$$

For roller bearings with point contact against one ring and line contact against the other:

*See *The Engineers' Digest*, Vol. 9, Nov. 1948, pp. 369-371, Vol. 10, Jan. 1949, pp. 15-19, and April 1949, pp. 123-126.

TABLE I.

	Line contact			Point contact		
	Radial bearing	Thrust bearing		Radial bearing	Thrust bearing	
		$\alpha \neq 90°$	$\alpha = 90°$		$\alpha \neq 90°$	$\alpha = 90°$
γ =	$(D_a/d_m)\cos\alpha$	$(D_a/d_m)\cos\alpha$	D_a/d_m	$(D_a/d_m)\cos\alpha$	$(D_a/d_m)\cos\alpha$	D_a/d_m
	Inner ring			Inner ring		
f_1 =	21·2	56·2 η	56·2 η	4·1	10 η	10 η
f_2 =	$\gamma^{2/9}(1-\gamma)^{29/27}/(1+\gamma)^{1/4}$		$\gamma^{2/9}$	$\gamma^{0{\cdot}3}(1-\gamma)^{1{\cdot}39}/(1+\gamma)^{1/3}$		$\gamma^{0{\cdot}3}$
f_α =	$(\cos\alpha)^{7/9}$	$(\cos\alpha)^{7/9}\tan\alpha$	1	$(\cos\alpha)^{0{\cdot}7}$	$(\cos\alpha)^{0{\cdot}7}\tan\alpha$	1
	$C_{il} = \lambda f_1 f_2 f_\alpha (il_a)^{7/9} Z^{3/4} D_a^{29/27}$			$C_{ip} = \lambda f_1 f_2 f_\alpha i^{0{\cdot}7} Z^{2/3} D_a^{1{\cdot}8} \times \left\{(2R/D_a)/[1-(R/r_i)]\right\}^{0{\cdot}41}$		
	Outer ring			Outer ring		
f_1 =	20·4	56·2 η	56·2 η	3·94	10 η	10 η
f_2 =	$\gamma^{2/9}(1+\gamma)^{29/27}/(1-\gamma)^{1/4}$		$\gamma^{2/9}$	$\gamma^{0{\cdot}3}(1+\gamma)^{1{\cdot}39}/(1-\gamma)^{1/3}$		$\gamma^{0{\cdot}3}$
f_α =	$(\cos\alpha)^{7/9}$	$(\cos\alpha)^{7/9}\tan\alpha$	1	$(\cos\alpha)^{0{\cdot}7}$	$(\cos\alpha)^{0{\cdot}7}\tan\alpha$	1
	$C_{el} = \lambda f_1 f_2 f_\alpha (il_a)^{7/9} Z^{3/4} D_a^{29/27}$			$C_{ep} = \lambda f_1 f_2 f_\alpha i^{0{\cdot}7} Z^{2/3} D_a^{1{\cdot}8} \times \left\{(2R/D_a)/[1-(R/r_e)]\right\}^{0{\cdot}41}$		

Note: The subscripts l = line contact, p = point contact, i = inner ring, e = outer ring.

$$C = 0{\cdot}80\, C_l^{0{\cdot}4}\, C_p^{0{\cdot}6} \quad .. \quad .. \quad (5)$$

$$L = (C/F)^{10/3} \quad .. \quad .. \quad .. \quad (5')$$

where L is in millions of revolutions.

The basic capacity for thrust bearings with two rows of similar roll bodies acting in the same direction and with different numbers of roll bodies, Z_1 and Z_2, respectively, is found from the basic capacities for each row, C_1 and C_2, calculated as single-row bearings after which the resultant dynamic capacity is determined from

$$C = (Z_1 + Z_2)/[(Z_1/C_1)^w + (Z_2/C_2)^w]^{1/w} \quad (6)$$

where $w = 10/3$ and $9/2$ for ball bearings and roller bearings respectively.

SIMPLIFIED METHOD

With a bearing having point contact under zero load, the conformity between the rollers and the bearing rings is so intimate that the contact area under load spreads out over the whole or the greater part of the roller length. For a bearing having a line contact, one must arrange for a certain amount of crowning if edge loading is to be avoided.

As a rule, therefore, the contact between the rollers and the raceways transforms from a point contact to a line contact after reaching a certain load, and the life exponent varies from 3 to 4 for different loading intervals within the same bearing.

It is thus desirable to have a uniform method of calculation which will be applicable to all types of roller bearings and for all loading intervals. The following method has been found convenient for practical work. In all cases, the life formula used is

$$L = (C/F)^{10/3} \quad .. \quad .. \quad (7)$$

For the determination of the basic capacity C, the equation used is

$$C = \nu\, C_{il}/[1 + (C_{il}/C_{el})^{9/2}]^{2/9} \quad .. \quad (7')$$

where C_{il} and C_{el} are both calculated for line contact as shown in Table III. The correction factor ν takes account of the fact that the exponent in the life formula is reduced to 10/3. For the range $L = 100$ to 10,000

TABLE II.

Radial bearings	λ	ν	$\lambda\nu$
Self-aligning ball bearings	1·0	—	—
Single-row deep groove ball bearings	0·95	—	—
Double-row deep groove ball bearings	0·90	—	—
Angular contact ball bearings ..	0·95	—	—
Cylindrical roller bearings with two modified line contacts	0·57	1·36	0·78
Cylindrical, tapered and spherical roller bearings with one point contact and one line contact	0·54	1·26	0·68
Cylindrical and tapered roller bearings with two line contacts	0·45	1·36	0·61

Thrust bearings	λ	k	$\eta\nu$	ν	$\eta\lambda\nu$	$\eta\lambda$
Single-row ball thrust bearings ($\alpha = 90°$)	0·7–0·9	0·15–0·33	0·60	—	0·60	0·6–0·65
Spherical roller thrust bearings ($\alpha = 50°$)	0·54	0·15	0·48	1·26	0·60	0·48–0·51

millions of revolutions, three different values of ν are employed:—

(a) both contacts are line contacts: $\nu = 1{\cdot}36$,
(b) both contacts are point contacts: $\nu = 1{\cdot}20$,
(c) one contact is line contact, the other point contact: $\nu = 1{\cdot}26$.

Table III gives the formulae required for the calculation of the basic dynamic capacity. For completeness, the formulae for ball bearings are also included. The only fundamental change for these is a decrease in the size-relation function $F(D_a)$ for $D_a >$ 25·4 mm. Units: kg and mm.

The formulae for roller bearings are valid with equal effective roller lengths of contact against both rings of the bearing. If in practice the contact length l_a is different with the respective rings, the lowest values should be used. The values of η, λ and ν are given in Table II.

EQUIVALENT LOADS FOR ROLLER BEARINGS

The following symbols are used:—F_r = actual radial load, F_a = actual thrust load, P_r = equivalent

TABLE III.

	Ball bearings			Roller bearings		
	Radial bearings	Thrust bearings		Radial bearings	Thrust bearings	
		$\alpha \neq 90°$	$\alpha = 90°$		$\alpha \neq 90°$	$\alpha = 90°$
$\gamma =$	$(D_a/d_m)\cos\alpha$	$(D_a/d_m)\cos\alpha$	D_a/d_m	$(D_a/d_m)\cos\alpha$	$(D_a/d_m)\cos\alpha$	D_a/d_m
$f_a =$	$(\cos\alpha)^{0{\cdot}7}$	$(\cos\alpha)^{0{\cdot}7}\tan\alpha$	1	$(\cos\alpha)^{7/9}$	$(\cos\alpha)^{7/9}\tan\alpha$	1
$f_1 =$	4·1	$10\,\eta$	$10\,\eta$	21·2	$56{\cdot}2\,\eta$	$56{\cdot}2\,\eta$
$f_2 =$	$\gamma^{0{\cdot}3}(1-\gamma)^{1{\cdot}39}/(1+\gamma)^{1/3}$		$\gamma^{0{\cdot}3}$	$\gamma^{2/9}(1-\gamma)^{29/27}/(1+\gamma)^{1/4}$		$\gamma^{2/9}$
$f_4 =$	$[(1-\gamma)/(1+\gamma)]^{1{\cdot}72}$			$[(1-\gamma)/(1+\gamma)]^{143/108}$		
$f_3 =$	$1{\cdot}04\,f_4$	f_4	1	$1{\cdot}04\,f_4$	f_4	1
$C_{il}/C_{el} =$	$f_3[(r_i/r_e)(2r_e - D_a)/(2r_i - D_a)]^{0{\cdot}41}$			f_3		
$g_c =$	$1/[1 + (C_{il}/C_{el})^{10/3}]^{0{\cdot}3}$			$1/[1 + (C_{il}/C_{el})^{9/2}]^{2/9}$		
$f_c =$	$\lambda\, g_c f_1 f_2/[1 - (D_a/2r_i)]^{0{\cdot}41}$			$\nu\,\lambda\, g_c f_1 f_2$		
$F(D_a) =$	$D_a^{1{\cdot}8}$ for $D_a \leq 25{\cdot}4$ mm $3{\cdot}64\, D_a^{1/4}$ for $D_a > 25{\cdot}4$ mm			$D_a^{29/27}$		
$C =$	$f_c f_a i^{0{\cdot}7} Z^{2/3} F(D_a)$			$f_c f_a (il_a)^{7/9} Z^{3/4} F(D_a)$		
$L =$	$(C/P)^3$			$(C/P)^{10/3}$		

radial load. On the basis of the test results carried out since 1947†, the equivalent radial load P_r can be calculated by means of the following formulae for *spherical and tapered roller bearings*:—

Single-row bearings:

$F_a/F_r \leq 1{\cdot}5 \tan\alpha$; $P_r = F_r$

$F_a/F_r > 1{\cdot}5 \tan\alpha$; $P_r = 0{\cdot}4\,F_r + 0{\cdot}4\,F_a \operatorname{cotan} \alpha$.

†See *The Engineers' Digest*, Jan. and April, 1949, for the formulae for ball bearings and for a numerical example on equivalent loads.

Double-row bearings:

$F_a/F_r \leq 1{\cdot}5 \tan\alpha$; $P_r = F_r + 0{\cdot}45\,F_a \operatorname{cotan} \alpha$

$F_a/F_r > 1{\cdot}5 \tan\alpha$; $P_r = 0{\cdot}67\,F_r + 0{\cdot}67\,F_a \operatorname{cotan} \alpha$

For combined applications (two bearings with lives L_1 and L_2 and point and line contact), the resultant life is obtained from

$$1/L = [(1/L_1)^{w_1} + (1/L_2)^{w_2}]^{1/w_{res}}$$

where $w_{res} = 2w_1 w_2/(w_1 + w_2)$, and w_1 or w_2 have the value 10/3 for point contact and 9/2 for line contact.

SWITZERLAND

The Measurement of Non-Electrical Quantities

By C. VON BASEL. (From a paper presented before the *Swiss Society for Materials Testing* (*SVMT*), at the Federal Technological University (ETH), Zurich, on December 14, 1951, 17 pages, 43 illustrations.)

After reviewing various methods hitherto employed for the electrical indication of non-electrical quantities, this report describes a transducer or pick-up arrangement consisting of sliding inductance cores in an impedance bridge for amplitude modulation. The units can be used for static and dynamic measurements. A special transmission element is described which enables signals from transducers on rotating parts to be transmitted inductively to stationary elements without using slip rings. The various designs developed include a 4-mm strain-measuring element as well as torque meters, torsional vibration indicators, and dynamic pressure pick-ups.

THE electrical measurement of mechanical quantities came into great prominence as a result of the rapid advances in technology achieved in the period which began shortly before the last war. As compared with purely mechanical means of measurement, electrical measuring systems have considerable advantages, viz.:— greater sensitivity and discrimination, possibility of monitoring and recording at any distance from the measuring position, static measurements as well as dynamic measurements up to high frequencies, ease of measurement, simplicity of direct readings and evaluation, less maintenance and less costly designs for the sensitive elements or pick-ups converting the mechanical quantities investigated into electrical signals.

If the use of equipment of this type is not even more widespread than it is at present, this is because no satisfactorily standardised equipment has hithero been available. A large number of electronic measuring methods has been developed and no possibility was left unexplored in an endeavour to utilise all types of physical phenomena as a basis for new methods of measurement.

VARIOUS METHODS OF MEASUREMENT

It will be of interest to consider some of the best-known methods.

The *carbon-pile* method makes use of the resistance variation of a column of thin carbon discs under compression. Even with a fairly high preload, it is difficult, owing to hysteresis effects, to obtain reproducible results, since any load exceeding the maximum load of the calibration will alter the calibrated values.

The *electrodynamic method* uses a permanent magnet and a moving coil provided with an elastic suspension which enables it to move in the air gap. With this method, the e.m.f. generated is low even at fairly high velocities. Very slow movements, or quasi-static processes which occur once only, cannot be indicated at all with this equipment, which cannot be calibrated statically. The moving coil system also has a low natural frequency, which makes it unsuitable for many applications.

Until recently the *piezo-electric method* was extensively used for measurements. When pressure is applied on a quartz crystal, this generates an electrical charge, which produces a voltage when applied to the plates of a capacitor. The system is sensitive to cable vibrations, and discrepancies due to zero-drift occur in the d.c. amplifier connected to the pick-up.

The *strain-gauge method* with resistance-wire strain gauges has been increasingly employed in recent years. The fact that strain alters the resistance of a wire was known already in the earliest days of electrical measurements, but the principle was not extensively applied until recently. A disadvantage with resistance-wire strain gauges is their unsuitability for static calibrations before and after dynamic tests. Further experience in the use of these strain gauges, based on very careful measurements made by Dr. Czerlinsky, has been summed up by Dr. Merz in an article published in " Archives of Technical Measurements "* as follows:—

In view of the many factors which cannot be controlled, it is difficult to accept statements that errors can be less than 3 per cent in static measurements, or less than 5 per cent in dynamic measurements with these strain gauges.

Changes in temperature produce electrical and mechanical effects. Even with constantan-wire strain gauges in a bridge arrangement, temperature variations can affect the zero reading as well as the peak-amplitude value. Mechanical effects due to temperature occur when the specimen and the gauge wire have different thermal expansion coefficients. Furthermore, the modulus of elasticity of the adhesive is much lower than that of constantan or steel, and it can thus reach much greater elongations without going beyond its yield point.

In addition, the effect of insulation should also be taken into account. A stress of 7100 psi corresponds to a strain of 0·025 per cent for steel. To obtain stress values with an accuracy of 1 per cent, the strain measurements must therefore be accurate to 5×10^{-6}. This means that soldered and other circuit connections must be reliable to 0·0006 ohm, when using strain gauge elements of 120 ohms resistance. This is a very stringent requirement for the circuit. Furthermore, the in-

*L. MERZ: Strain measurement with resistance-wire strain gauges. *Archiv für technisches Messen*, V-91122-11, July 1950; and V-91122-12, August 1950.

sulation resistance in parallel with the wire must have a value of 600 megohms, and the insulation resistance to earth must not be less than some 100 megohms. These difficulties with resistance-wire strain gauges do not seem to have been fully appreciated in many cases, and defective insulation resistance may be the reason for the unsatisfactory results complained about in various technical papers.

REQUIREMENTS FOR VIBRATION-MEASURING EQUIPMENT

Vibration-measuring equipment may be regarded as technically efficient if it is universally applicable and also fulfils the following requirements :—

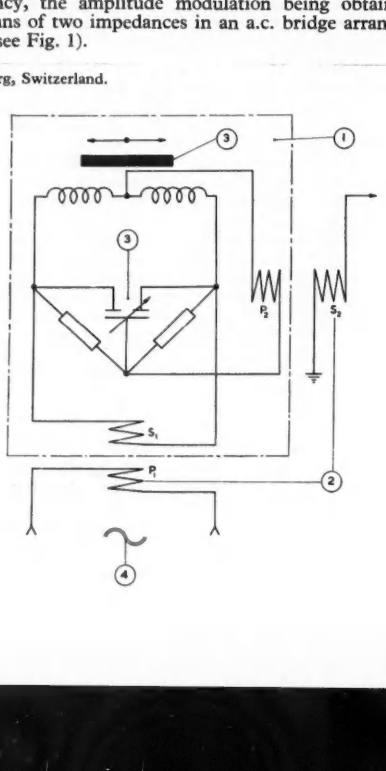
(1) Zero point stability over long periods of time.
(2) Temperature stability and reproducibility of results without hysteresis effects.
(3) High natural frequency and adequate damping.
(4) High sensitivity with a minimum use of amplification, simplicity of operation, mains-operated equipment independent of network fluctuations.
(5) Constancy of response unaffected by replacement of circuit components such as valves.
(6) Suitability for static calibration before and after each test.
(7) Independence of cable capacitance effects and cable length.
(8) Insensitivity to stray fields of electrical or magnetic origin.
(9) Operation without slip rings, i.e., freedom from disturbing effects due to mechanical contact (wear, contact resistance variation, thermal voltages, etc.).

NEW MEASURING EQUIPMENT

A new range of industrial electronic measuring equipment has been produced by the Vibro-Meter Company.* All the elements are standardised and a minimum outlay of equipment is required for static and dynamic measurements in widely different fields of application.

The measuring system comprises a transducer element or pick-up and an electronic apparatus specially designed for industrial applications. The system is based on the use of an amplitude-modulated carrier frequency, the amplitude modulation being obtained by means of two impedances in an a.c. bridge arrangement (see Fig. 1).

*Fribourg, Switzerland.



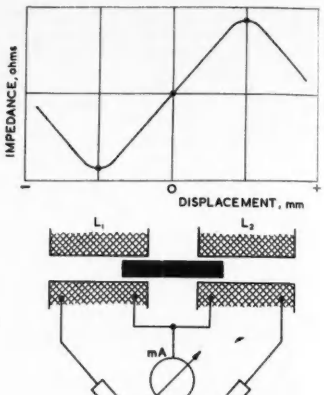


Fig. 1. **Variation of impedance as a function of the position of the inductance core.**

The impedance variation is linear over a wide range, and is determined by the position of the inductance core, as shown in the diagram of Fig. 1. Two impedances, generally of the inductive type, form the measuring element of the pick-up and are of very small dimensions for carrier frequencies of some thousands of cycles per second. The core is of " invar " alloy, and temperature compensation is maintained to fairly high temperatures by using suitably selected materials for the pick-up. The mechanical centre of the pick-up coincides with the electrical centre of the system.

To eliminate stray-field effects, the impedance coils are wound in opposite directions. The carrier frequencies are as high as 50 kcps so that cable effects are unimportant. The pick-up construction is extremely simple As the pick-up is fed with an adequate amount of power, the general sensitivity to external disturbances is low, and the amplification of the electronic apparatus is thus maintained within reasonable limits.

For measurements on rotating parts, no slip-rings or brush-gear are required, and the slipringless transmission is free from wear and maintenance problems. Signal transmission from rotating to stationary elements

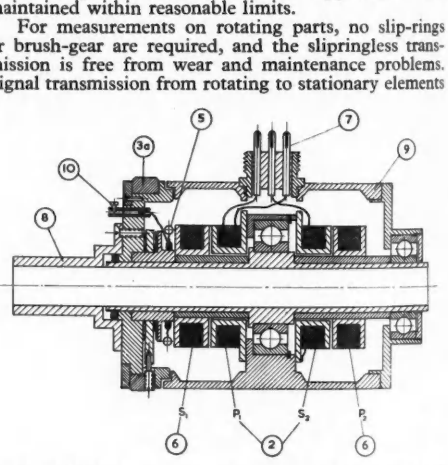


Fig. 2. **Slipringless rotary signal transmitter, developed by Dr. von Basel.**

(1) = Rotating impedance bridge ; (2) = stationary coils ; (3) = balancing for amplitude and phase ; (3a) = knurled ring for phase balancing ; (4) = carrier frequency ; (5) bridge resistances ; (6) = rotating coils ; (7) = cable connections ; (8) = hollow stub shaft ; (9) = stationary casing ; and (10) = terminals (three at 120 deg.) for connections to pick-ups.

of the system is by means of two coils, situated fairly close to each other, and arranged so that one is able to rotate while the other remains stationary (Fig. 2). To avoid any wobbling effects, the system is designed so that the magnetic coupling of the two coils is not affected by angular misalignment. In this arrangement, the entire impedance bridge rotates with the shaft and the bridge supply voltage, which is the actual carrier, is transmitted inductively by means of a stationary primary coil P_1 to a rotating secondary coil S_1. The bridge output is then transferred from a rotating primary P_2 to a stationary secondary coil S_2.

The electronic equipment is made in two different models, for linear-displacement and rotary-type pick-ups, respectively. In the first model, the balancing elements for amplitude and phase are included in the apparatus, whereas in the second model the compensation is arranged in the pick-up. In both models, the circuits include an 8-kcps oscillator, a single-stage amplifier, a " magic eye " type bridge balance indicator, and a single-valve output stage following a sensitivity control and a demodulator. The systems are mains-operated with voltage stabilisation. In both models, the output can be applied to a galvanometer oscillograph or a pen recorder, the output signal reaching a maximum amplitude of $\pm$ 40 mA with a matching resistance of 1 to 10 ohms. The units are also available with cathode-ray oscillographs for monitoring purposes. Other units have been designed with a 50-kcps carrier frequency for extra-high-speed work, and a 50-cps (mains) carrier frequency suitable for static or slowly-varying phenomena. Combined units, with outputs applied to both the x- and the y-plates of the oscillograph, have also been developed.

MEASUREMENT ACCURACY

For dynamic measurements, the accuracy of indication is about 1 to 2 per cent.* Static measurements can be obtained with an accuracy of 0·02 per cent, with a linear response up to $\pm$ 15 mm displacement, by means of the Vibro-Meter measuring bridge, which operates as a null-indicator. Two of the bridge inductances form the pick-up element (Fig. 3) and are connected through a cable to the other two compensating arms which are adjustable for zero output by means of a micrometer screw. Readings are accurate to four places of decimals, and recalibration is not necessary provided the pick-up is not exposed to high overloads.

STRAIN-MEASURING EQUIPMENT

The strain-gauge elements consist essentially of two small tubes which can slide into each other, each tube being attached to the structural component under investigation by means of small holders or mounting blocks. On machine parts working under rough operating conditions, these blocks may be soldered or spot-welded to the measuring positions. For small gauge lengths, the element is set on the test structure by means of contact points and clamps (Fig. 4), and held in position by means of suction pads. The moving core is in this case attached to a flexible member which prevents any tilting of the pick-up. The gauge includes a micrometer head for calibration and adjustment.

*Recording accuracy depends, however, on the type of recording devices used, and considerable information on this subject is given in an article by W. HAERTEL in *Archiv für techn. Messen*, J035-6, July 1950; and J035-7, August 1950.

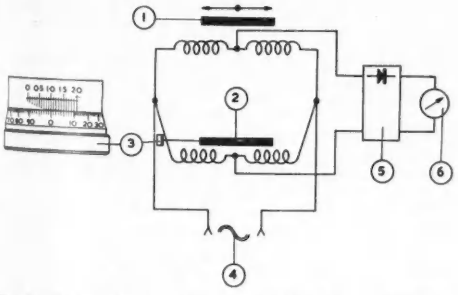


Fig. 3. **Schematic diagram of Vibro-Meter measuring bridge (50 kcps carrier frequency).**
(1) = Pick-up; (2) = zero balancing; (3) = micrometer drum for balancing adjustment; (4) = 50 kcps carrier frequency; (5) = demodulator; and (6) = null instrument.

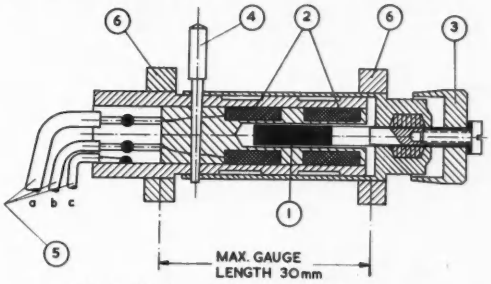


Fig. 4. **Static and dynamic strain gauge.**
(1) = Sliding core; (2) = inductance coils; (3) = calibrated drum with scale; (4) = stopping pin; (5) = cable connections; and (6) = mounting blocks.

Strain-measuring elements with adjustable gauge lengths have also been developed, by using a leaf-spring fixture which transmits axial strains only, without lost motion due to tilting or twisting (Fig. 5). In some designs, the holding members include a ball-and-socket arrangement, which can also be used on curved surfaces. Special water-tight elements have been produced for use on dams.

In cases where many measurements have to be taken in rapid succession to determine stress distribution, e.g., on a large structure or a ship's hull, the ball-and-socket arrangements can be used in conjunction with magnets to hold the fixture supports at the test positions. Small permanent magnets with great holding power, provided with short steel contact points, make it possible to set the pick-up on a definite gauge length.

For the determination of stress-concentration factors on curved surfaces with high stress gradients, a 4-mm ($^5/_{32}$ in.) strain-measuring element has been produced (see Fig. 6). The sliding-coil system is mounted on a fixture consisting of two arms held in place by an elastic stud which is subjected only to a compressive load. The method of attachment is such that the pressure with which the fixture is held against the test

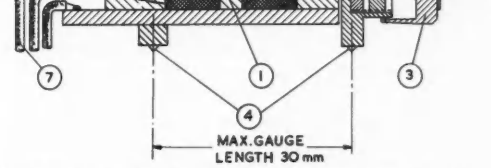


Fig. 5. **Strain gauge with measuring points and adjustable gauge length.**
(1) = Sliding core; (2) = inductance coils; (3) = calibrated drum; (4) = measuring points; (5) = flexible member; (6) = adjustable block; and (7) = cable connection.

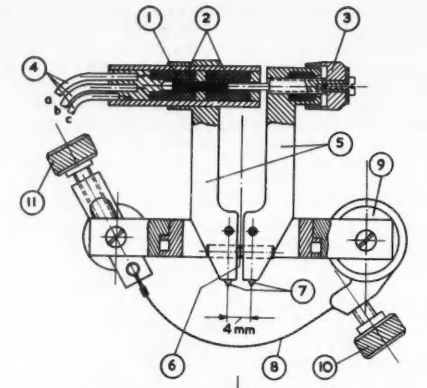


Fig. 6. **Strain gauge with 4 mm gauge length, suitable for static and dynamic measurements.**

(1) = Sliding core; (2) = inductance coils; (3) = balancing micrometer; (4) = cable connections; (5) = carrier body; (6) = flexible element; (7) = measuring points; (8) = band clamp; (9) = feed drum for band clamp; (10) = band clamping screw; (11) = screw for fine adjustment of band tension; and (12) = angular pivoting device.

position has no effect on sensitivity. The measuring element can be set on the surface at any required angle relative to the main line of curvature. Measurements with this pick-up can have a maximum amplification of 10^6.

ACCELERATION TYPE PICK-UPS

The high sensitivity of the sliding-core system makes it particularly suitable for acceleration type pick-ups with a high natural frequency and adequate damping. The seismic mass is connected to the pick-up body by means of springs or diaphragms, which are stiffened to such a degree that natural frequencies of up to 2000 cps are obtained. Viscous damping, proportional to velocity, is provided by using silicone fluids which have a viscosity independent of temperature. The pick-ups are calibrated by tilting them through an angle of 90 degrees, this giving a static deflection corresponding to an acceleration of 1 *g* or 32·2 ft/sec^2.

A sectional drawing of the universal diaphragm-type pick-up is shown in Fig. 7. This unit can also be used with a needle follower or as a pressure pick-up. Models with extremely small dimensions have also been developed.

For measurements of rapidly varying gas pressures or fluid pressures, particularly in engine systems, a pressure-indicator pick-up has been designed so that it can be screwed into the combustion chamber. For measurements at temperatures above 80° C (176° F), the pick-up is provided with a water cooling arrangement. Its natural frequency is above 50 kcps. For very low pressures and differential pressures of the order of 1 mm Hg, and for low-pressure diagrams of intake and exhaust fluctuations, a double-diaphragm pick-up has been produced. Its natural frequency is close to 2000 cps.

Further types of pick-ups include degree-marking

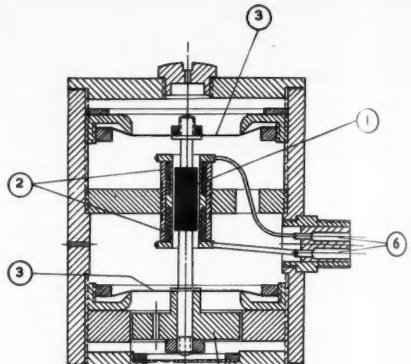


Fig. 7. **Universal diaphragm-type pick-up, adaptable for use as a seismic-mass, needle-follower, or pressure-sensitive element.**

(1) = Sliding core; (2) = inductance coils; (3) = diaphragms; (4) = damping; (5) = seismic mass; and (6) = cable connections.

and time-marking capacitive pick-ups with eccentric or spiral-type rotors, and rotary capacitive or inductive pickups for the measurement of angular acceleration. These are used in conjunction with the slipringless transmitter unit already mentioned (see Fig. 2).

Compressive loads up to 100,000 kg may be measured with the specially designed heavy-pressure pick-ups which can be used in rolling mills, presses, materials testing machines, etc. The units are suitable for both static and dynamic measurements. To eliminate eccentric loading effects due to non-parallel test surfaces, the pick-up diaphragm is loaded through a self-compensating ball-and-socket system of suitable size.

TORQUE-MEASURING EQUIPMENT

The impedance-type torque-measuring unit is designed as a flanged coupling which can be fitted between the driving shaft and the driven shaft in order to measure transmitted mean torque and vibratory torque. The torsion shaft is of a beryllium alloy which gives a stress-strain diagram without hysteresis effects. At either end of the calibrated measuring portion and at a distance equal to the gauge length, two flanges are fitted, which carry the inductive elements for the measurement of the very small angle of twist. To eliminate the effect of any possible bending moments, the inductive elements are mounted in a self-compensating arrangement at 180 degrees relative to each other on the shaft. The torque meter is employed in conjunction with the inductive transmission unit so that no slip-rings are necessary.

IRON AND STEEL MAKING IN THE U.S.A.

Concluded from page 207.

with increased use of fuel oil and the introduction of the continuous working week, has already given an increase of 25 per cent in the output of finished steel per man.

The Team urges a continuation of at least the current expenditure by the British steel industry. At present prices £30 millions must be spent each year merely to maintain existing capacity. Plans are, however, now being made to increase the present capacity, and the Team considers that an annual capacity of around 20 million ingot tons could be reached in a reasonable time only if annual capital investment of £60 millions is maintained or even exceeded.

The Effect of Quench-Ageing on the Notch Sensitivity of Steel

By J. R. Low, Jr. (From *The Welding Journal*, Vol. 31 No. 5, May 1952, pp. 253s-256s, 6 illustrations.

Quench-ageing is sometimes responsible for the brittle zone adjacent to welds in semi-killed mild steel and in such cases may be improved by a low temperature post-heat treatment.

THE fact that strain-ageing may raise the notched bar impact transition temperature of mild steel is now well recognised. The fact that quench-ageing also occurs in this class of steels and may also raise the impact transition temperature has not received as much attention as a possible factor in the brittle failure of welded structures. The thermal cycle required to initiate quench-ageing, i.e., a short time of heating in the range of 500 to 700° C followed by rapid cooling, may well occur in the heat-affected zone immediately adjacent to a weld, particularly in heavy plates. That portion of the base metal which experiences such a thermal cycle can then be expected to decrease in ductility with time of ageing at room temperature, ultimately leading to a brittle region having a much higher transition temperature than the unaffected base metal. This brittle region may be partially eliminated by a short-time low-temperature post-heating in the neighbourhood of 350° C.

Quench-ageing effects may also be produced, but to a lesser degree, by slow cooling from the 500-700° C temperature range. It is believed that the precipitation which occurs during such slow cooling is at least partially responsible for the generally observed effect of thickness on the impact transition temperature of as-rolled mild steel plates, i.e., that the heavier the plate the higher is the transition temperature.

Experimental Procedures

The material used throughout this investigation was a semi-killed steel, in the form of ½-in. hot-rolled plate of the following analysis: C, 0·17; Mn, 0·75; P, 0·017; S, 0·035; Si, 0·044.

Standard key-hole Charpy specimens were cut from the plate with their long axes parallel to the rolling direction and with their notch axes perpendicular to the plate surface. The specimens were prepared except for notching, heat treated, and then notched. Those specimens designated "as-quenched" were notched and tested within five hours of quenching. During this time they were kept at 0° C except for the short time required to drill and slot the standard notch.

The quench-ageing heat treatment consisted of heating for five minutes at 690° C in a lead bath, water quenching and then ageing at room temperature for periods up to three years. The short time at the solution annealing temperature was felt to be adequate for saturation of the ferrite by carbon or nitrogen but not long enough to cause pearlite spheroidisation or changes in ferrite grain size. No microscopic evidence could be found for any structural changes as a result of this solution anneal.

The impact testing procedure consisted of cooling or heating the specimens in an appropriate bath of dry ice and acetone, ice and water, or warm water and then breaking in a standard impact machine. Where the test required heating above room temperature the time in the bath was limited to a maximum of three minutes to minimise accelerated ageing during heating for impact testing.

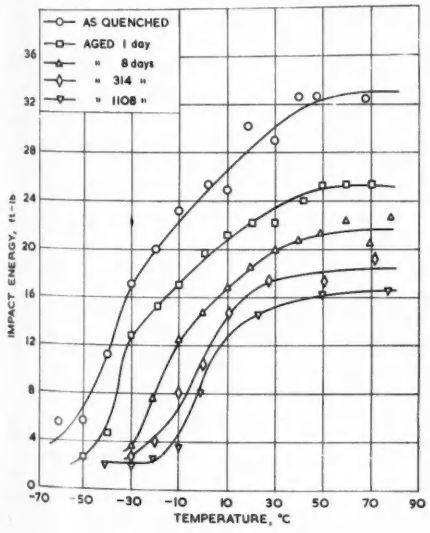


Fig. 1.

Effect of Quench-Ageing on the Impact Transition Temperature

The impact energy versus temperature curves obtained for various room temperature ageing times up to 1108 days are shown in Fig. 1. Each of the experimental points shown is the mean of three test values; in only three cases did the energy values which were averaged differ by more than 4ft-lb. If the transition temperature is taken as the temperature at which the impact energy curve falls to 10 ft-lb, Fig. 1 shows that the transition temperature has been raised from approximately —40° C to 0° C as a result of quench-ageing. The rate at which the transition temperature shifts as a result of quench-ageing is better illustrated in Fig. 2 where this transition temperature is plotted against the time of room temperature ageing. A very rapid increase in transition temperature occurs during the first ten days after quenching, followed by a slower rate of increase. However, even at the end of three years there is no indication that the transition temperature has begun to decrease due to overageing. In this same period, the hardness has reached a maximum of 90 Rockwell-B and begun to decrease. A second result is that the level of energy absorbed above the transition temperature has been drastically lowered from 34 ft-lb before ageing to about 17 ft-lb after three years' ageing.

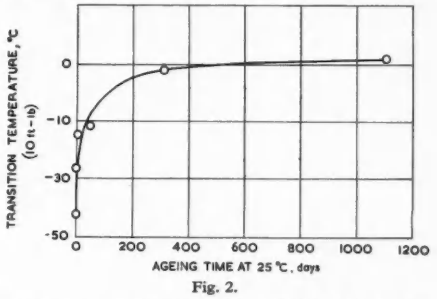


Fig. 2.

Additional impact strength data, obtained at more closely spaced time intervals, together with the change in fracture appearance as a function of ageing time

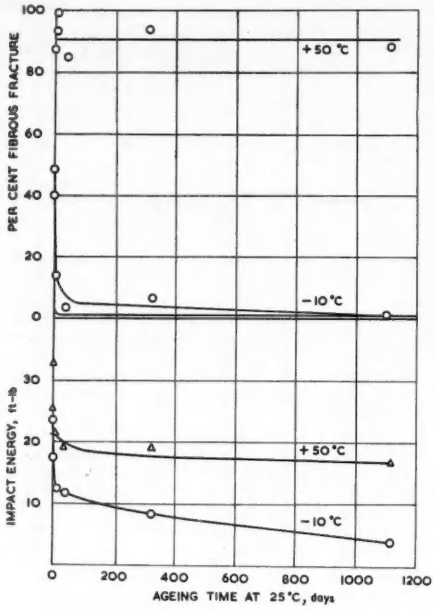


Fig. 3.

at room temperature, are shown in Fig. 3. Here the impact strengths at —10° C and +50° C are plotted against ageing time. At the longest ageing time, the transition temperature, which was initially well below —10° C is now above this temperature. In addition, the energy absorbed above the transition temperature (+50° C) is still falling. As may be seen in the upper part of Fig. 3, this latter decrease in impact strength at high temperature is not accompanied by a change in fracture appearance, indicating that the decrease results from a change in the flow curve of the material and not from a change in the mode of fracture.

Low-Temperature Post-Heating to Avoid Quench-Ageing Embrittlement

Low and medium carbon steels may be "overaged," i.e., returned to their original hardness, in a few minutes at temperatures above 100° C. If it could be demonstrated that these materials will also overage rapidly with respect to the change in transition temperature, then a welding procedure which included a low-temperature post-heating of the heat-affected zone should completely eliminate the danger of progressive embrittlement due to quench-ageing. Klingler and Ebert[1] report a region of low ductility in the heat-affected zone which they attribute to quench-ageing, although they did not study the effect of ageing time. In addition, they showed that post-heating at 593° C following welding would eliminate the region of lowered ductility in the heat-affected zone. The experimental results described below indicate that a considerably lower post-heating temperature might be used to bring about overageing in the brittle region without the risk of starting a quench-ageing cycle in the region adjacent to the post-heated portion of the weld.

Experiments to determine the optimum post-heating temperature were performed using changes in hardness for the preliminary exploration. Hardness specimens which had been quenched from 690° C and aged three years at room temperature were heated to various temperatures above room temperature, held two minutes, and then water quenched. This thermal cycle was chosen in an attempt to simulate a practicable post-heating cycle. The Rockwell "B" hardness values obtained for various reheating temperatures indicate an optimum temperature range for overageing between 350 and 400° C. Below this range, longer times of heating would be required and above it there is danger of starting another quench-ageing cycle by the re-solution of carbon or nitrogen.

The effect of heating to 350° C for five minutes and water quenching on the key-hole Charpy impact curve is shown in Fig. 4, where the curve for the overaged condition is compared with as-quenched and the as-quenched and aged conditions. The similarity of the two sets of data for the overaged condition, one for specimens overaged immediately following quenching, the other for specimens overaged after three years, indicates that the time elapsed between welding and post-heating would not be critical.

The results in Fig. 4 also show that a low-temperature post-heat treatment in the neighbourhood of 350° C should do much to eliminate the region of minimum ductility commonly observed adjacent to welds in this

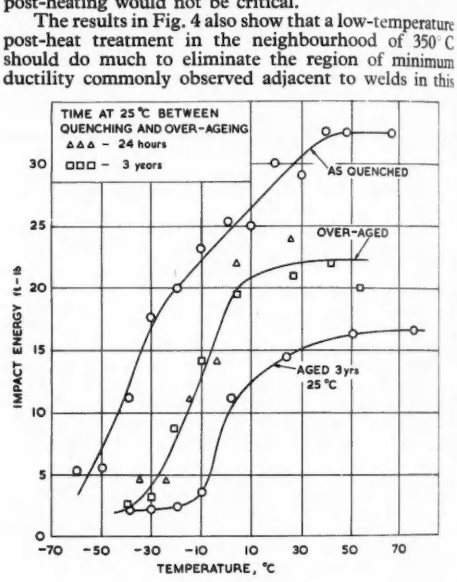


Fig. 4.

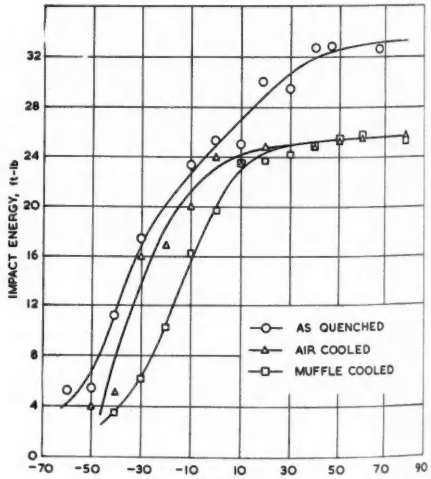


Fig. 5.

class of structural steels and markedly lower the temperature of brittle failure. Further, it seems probable that the demonstrated beneficial effects of the low temperature stress relief advocated by Greene[2,3] may well be due to overageing of the embrittled heat effect zone rather than to stress-relief alone.

Quench-Ageing During Sub-Critical Cooling of Hot-Rolled Plates

The precipitation responsible for the quench-ageing effects just described may be produced by quenching to a low temperature (e.g., room temperature) and ageing, or it may occur during cooling from the solution annealing temperature with cooling rates less than that which is attained in water quenching. In general, one would expect the effects of precipitation occurring during cooling to be less drastic than those obtained by quenching and ageing at a low temperature. The effect of decreasing the cooling rate on the impact energy-temperature curves on the mild steel used in the quench-ageing experiments is shown in Fig. 5. In an attempt to duplicate the cooling rate of a heavier plate, 48 specimens were hung in a sheet steel box, separated from each other by approximately $\frac{1}{8}$ in. This " muffle " was heated to 690° C and allowed to cool in air. From the measured cooling rate at the centre of the box of specimens, it is estimated that these specimens were cooled at a rate approximately the same as that which could be obtained at the centre of a $\frac{3}{4}$ in. plate during air cooling. The upward shift in transition temperature corresponding to the decrease in cooling rate from " air-cooled " to " muffle-cooled " is of the same order as that observed when $\frac{1}{2}$-in. and $\frac{3}{4}$-in. plates from the same heat are compared.

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GERMANY

The Manufacture of Reinforced Steel Tubing

By E. Hörmann. From *V.D.I. Zeitschrift*, Vol. 94, No. 11/12, April 21, 1952, pp. 343-345, 16 illustrations.

Steel tubes may be reinforced or flanged by upsetting under heat. Local induction heating is more suitable for this process than electric resistance heating since the rolling scale of the tube would interfere with the uniform direct transmission of the current. A magnetic yoke surrounds the induction coil, Fig. 1, and concentrates the magnetic effect onto a small ring zone of the tube wall which is heated uniformly to the upsetting temperature within a few seconds (Fig. 2). The tensile strength of the material at the temperatures reached at various points of the tube wall determines size and shape of the reinforcement.[1] Plastic deformation is usually restricted to regions heated above 750° C. The smoother the temperature transitions within the material, the smoother will be the transitions from the plain to the reinforced cross-sections after upsetting. The axial extension of the heated zone must be kept as short as possible. Folds and corrugations are avoided only if the heated length is less than three times the tube wall thickness,[2] and only by induction heating can such narrow zones be obtained. The heated tube wall is upset by axial pressure and forms collars outside and inside. The outer collar is thicker than the inner collar, since deformation towards the inside is restricted by the decreasing diameter (Fig. 3). The flow of the material can, however, be controlled or directed wholly towards one side if restricting mandrils or rings are used (Figs. 4 and 5).

If the induction coil is stationary and the tube is

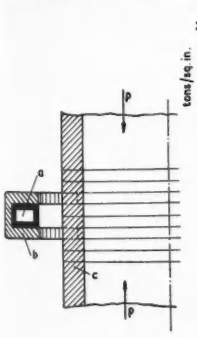

Fig 1.

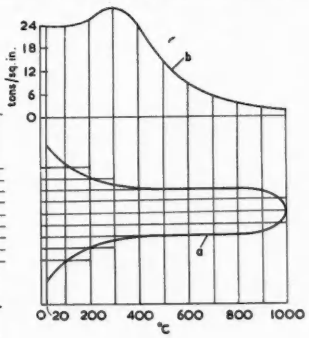

Fig. 2.

Fig. 1. **Schematic arrangement of induction coil for local heating of tubes.**

(*a*) = Induction heating coil; (*b*) = magnetic yoke; (*c*) = tube; (*p*) = upsetting pressure.

Fig. 2. **Temperature distribution and tensile strength across heated region (24-ton steel).**

(*a*) = Temperature; (*b*) = tensile strength at elevated temperatures.

Fig. 3.

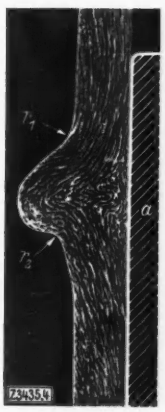

Fig. 4.

Fig. 3. **Unrestricted deformation *after* local inductive heating.**

Macro-etching. Magn. 5×. Reproduction half size.
h_a = Thickness of external reinforcement;
h_i = thickness of internal reinforcement;
s = tube wall thickness.

Fig. 4. **Local external reinforcement produced by upsetting *during* heating and insertion of an inner guiding mandril.**

Oberhoffer's reagent. Magn. 1·5× Repr. $\frac{2}{3}$ size.
a = Guiding mandril, r_1 and r_2 = transition radii ($r_1 > r_2$).

upset while the heating current remains switched on, the heated and upset material is pushed towards one side of the heated region and new material enters the zone and begins to be deformed. Consequently, the transition radius from tube to reinforcement is smaller where the upset material leaves the heated zone than where new material enters it (Fig. 4). Symmetrical reinforcements are only obtained if the tube is upset after heating or if the coil is displaced axially during upsetting. A continuous axial motion of the coil while the tube is held under constant upsetting pressure will create a uniform reinforcement over the length of travel. The upset material leaving the heated zone may have to be cooled artificially in order to prevent further deformation and to obtain a cylindrical reinforcement. Artificial cooling also refines the rolled grain structure. Narrow collars or end flanges may be produced by upsetting in a die.

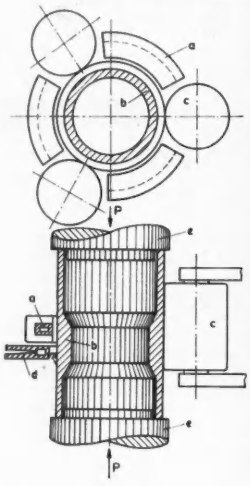

Fig. 5.

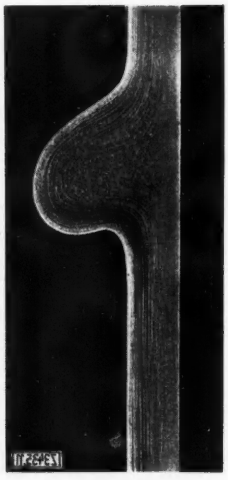

Fig. 6.

Fig. 5. Axially movable fixture for the manufacture of long internal reinforcements of tubes.

a = Segmental induction coils; *b* = tube; *c* = pressure rolls; *d* = water cooling; *e* = clamping chucks; *P* = axial upsetting pressure applied during travel of heated zone.

Fig. 6. Local internal tube reinforcement produced by stationary heating fixture as shown in Fig. 5.

Oberhoffer's reagent. Magn. 1·5×, Repr. $^{9}/_{10}$ size.

Internal reinforcements are more difficult to manufacture. A ring slipped over the heated tube causes heavy friction and rapid cooling so that a large upsetting pressure is needed. An internal induction coil, though possible with large tubes, is disadvantageous from an electrical point of view. A combined heating and rolling device (Fig. 5) has proved a better solution: three induction coil segments and three pressure rolls are arranged evenly around the circumference of the tube which is rotated under axial pressure and pressure from the rolls, while being heated by induction. Heat and circumferential roller pressure thus act uniformly over the entire tube circumference and enforce a uniform flow of metal into the bore. If the fixture is kept stationary, an asymmetrical reinforcement (Fig. 6) will again result from the axial flow of material into the continuously heated zone. A uniform axial movement of the fixture creates a cylindrical reinforcement (Fig. 7), of a thickness depending on the speed of the axial motion. Reinforcements of varying shapes can be obtained by suitable changes of roller pressure, speed of axial motion, and temperature of the heated zone, e.g.,

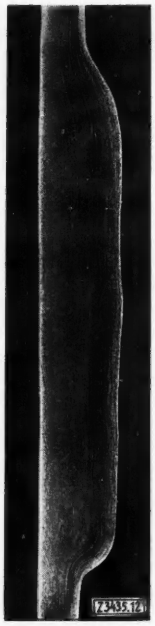

Fig. 7.

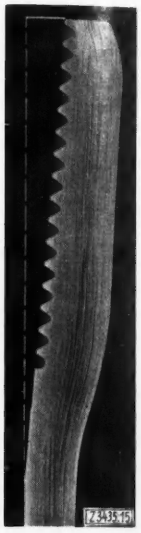

Fig. 8.

Fig. 7. Cylindrical internal tube reinforcement.

Oberhoffer's reagent. Magn. 1·5×, Repr. $^{3}/_{4}$ size.

Fig. 8. Tapered external pipe thread cut into tapered internal reinforcement.

Oberhoffer's reagent. Magn. 2×, Repr. $^{1}/_{2}$ size.

tapered reinforcements of considerable thickness for the cutting of tapered threads in thin tubes (Fig. 8) or for other purposes. The position of the rollers may be

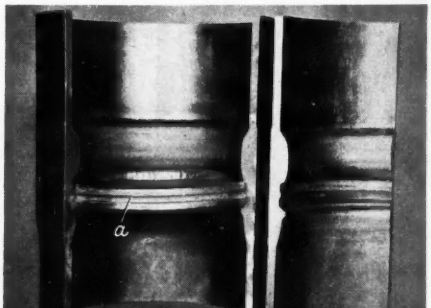

Fig. 9. Liner with internal disc *a* fixed rigidly into the tube wall by upsetting under inductive heating.

adjusted so that an external reinforcement of specified thickness results. Orifice discs may be positioned in the tube and firmly fixed by upsetting the tube material around the disc (Fig. 9). The plastically deformed tube material will completely fill any external profile given to the disc.

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New Materials, Processes and Equipment

NEW SURFACE GRINDING MACHINES

Arthur Scrivener Ltd., of Tyburn Road, Birmingham, have entered the field of surface-grinder manufacture, their largest model being shown in Fig. 1. The massive construction of this machine renders it extremely suitable for toolroom requirements as well as for continuous and heavy stock removal on production work, the rigidity of the motor drive (Fig. 2) permitting the heaviest cuts being taken without vibration. The model shown carries a wheel 10 in. in dia. by 1 in. wide mounted on a 2 in. dia. spindle 22 in. long, running at 1740 rpm. This spindle is carried in rigid phosphor-bronze self-lubricating bearings. A diamond truing device forms part of the standard equipment of the machine and is mounted on the wheelhead.

Fig. 1

The table has a working surface of 8 in. × 18 in. and a longitudinal travel of 19 in. operated either hydraulically or by hand, the valve gear in the former case permitting smooth reversal at speeds up to 40 fpm. This table is mounted on a substantial saddle having a cross travel of 9¼ in. The cross-feed is automatic in increments up to 0·050 in., actuated by trip dogs with automatic disengagement at any desired point. The handwheel for hand operation of the cross-feed is calibrated in divisions of 0·001 in. in its normal position, but a slight withdrawal of this handwheel engages a fine-feed device giving easy readings down to 0·0001 in.

The wheel head has power rise-and-fall movement operated by a separate motor for rapid setting. It has a maximum travel of 12 in., giving a clearance of 10 in. between the top of the table and the periphery of a new wheel. The power movement is controlled by a small hand-lever which permits the wheelhead either to be moved rapidly or inched when it approaches the work, final movement of the wheel being obtained by means of the fine-feed handwheel. An automatic interlocking device is provided to prevent any possibility of the simultaneous engagement of hand and power motions.

Slideways are of simple rectangular form with long narrow guides and efficient lubrication. Cross movement of the saddle is controlled by a narrow guide

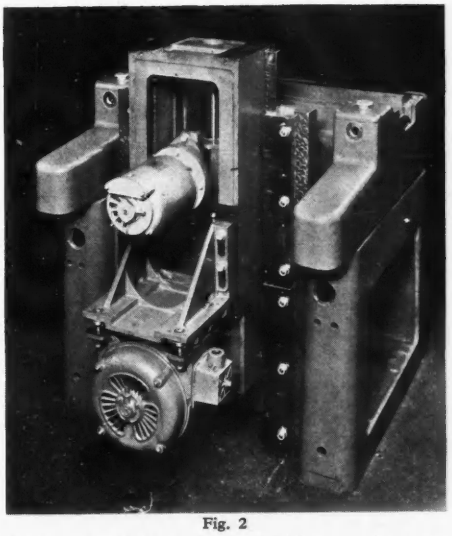


Fig. 2

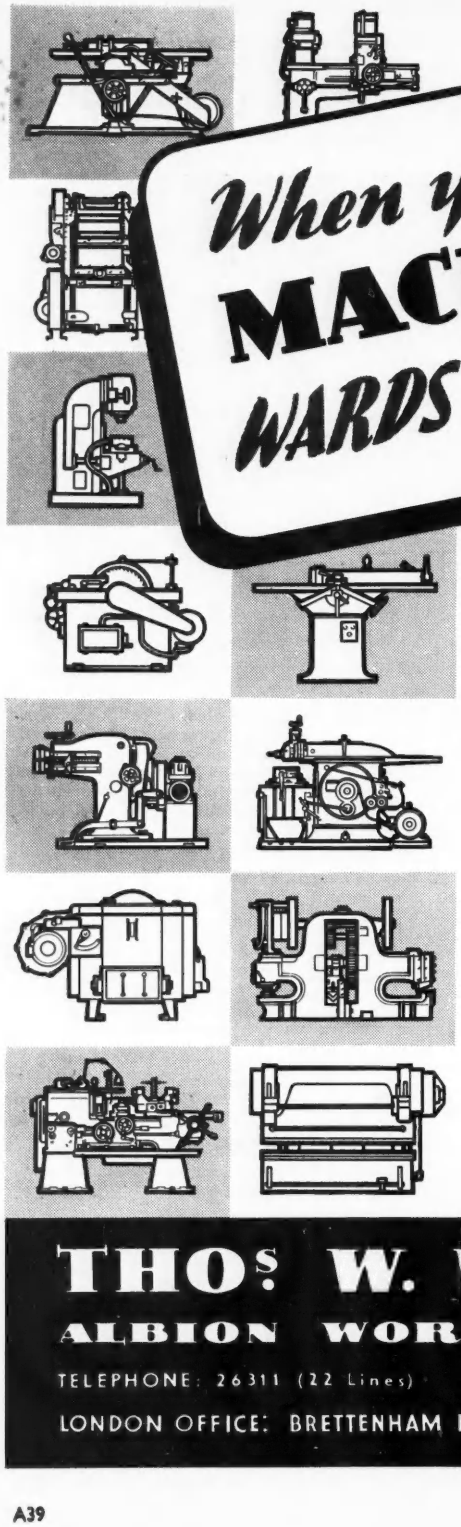
independent of the flat ways which carry its weight. The slideways remain covered throughout the full travel of the table and the saddle.

A motor-driven low-pressure pump, housed in the machine base, supplies power for all hydraulic movements, this pump with all the necessary fittings being mounted above the oil reservoir.

RE-DESIGNED PROFILING MACHINE

The Wade Tool Co. of Waltham, Mass., announce several new features which have been embodied in their motor-driven precision profiler. It is now much heavier, and has a powerful V-belt drive. Previously offered for bench mounting only, a pedestal metal cabinet has been designed as optional equipment.

The Wade profiler has new cutter holder collets with improved grip. The same collet is used in the follower spindle. A follower spindle parallel with the



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main spindle holds the follower spindle cutter for producing templates from sample.

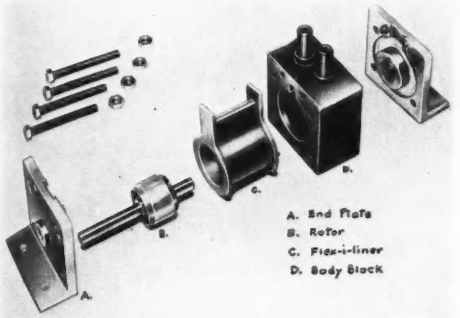
It is stated that this compact, rugged machine is especially designed for profiling, milling, slotting, recessing and routing operations on a great variety of small mechanical parts.

The profiler requires a floor space of 24 in. × 26 in., and is 57 in. high. A standard 1750 rpm, ⅓ hp 3-phase motor provides eight spindle speeds, ranging from 437 to 7000 rpm.

A 3450 rpm, ⅓ hp 3-phase motor provides eight spindle speeds, ranging from 875 to 14,000 rpm.

PUMP FOR CORROSIVE CHEMICALS

The unique design of the " Flex-i-liner " pump manufactured by Vanton Pump Corp., New York, is particularly adaptable for use in the chemical, pharmaceutical and food processing industries for handling highly corrosive acids, caustics, biological solutions, distilled water, slurries and food stuffs.



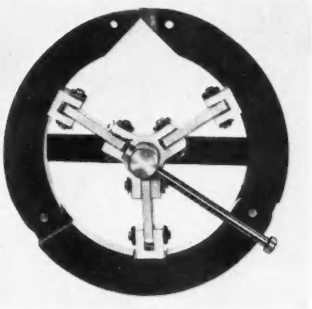
All Vanton pumps are self-priming and avoid typical sources of leakage by eliminating stuffing boxes, packing glands and gaskets. No lubrication is required. The absence of check valves also adds to the pump's simplicity. A rotor on a sealed-in ball bearing and mounted on an eccentric drive shaft rides inside and activates the " Flex-i-liner." Rotation produces a compressive action between the outside of this flexible member and the bore in the pump body block to draw fluid in at the inlet and carry it around the bore for delivery at outlet. Flanges on the " Flex-i-liner " positively seal off the fluid passageway from contact with any of the metal parts of the pump. The fluid is restricted to the outer surface of the " Flex-i-liner " and the inner surface of the body block. The latter part can be furnished in a wide variety of corrosion-resistant materials, such as bakelite, polyethylene and lucite. The " Flex-i-liner " is available in corrosion-resistant materials such as pure gum rubber, synthetic rubbers, vinyl and other plastic materials.

The pump units are available in capacities from fractional to 20 gpm in discharge pressure ranges from zero to 75 psi requiring ¼ to 1½ hp constant-speed motors

PIPE EXPANDERS AND INTERNAL PIPE ALIGNERS

Modern welded pipelines need to be constructed from pipe sections which are exactly internally aligned. As all pipes suffer from varying degrees of ovality, mechanical aids are necessary to ensure that pipes are held truly round so that perfect flame cut bevels can be produced, and to hold the pipes in perfect internal alignment whilst the butt welds are being made.

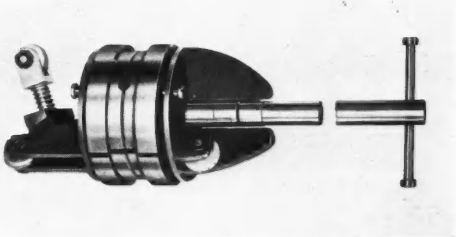
In the first instance, Twinner Pipe Expanders are used to press out the walls of a pipe to a truly round form. When in place, an oxy-acetylene pipe cutter is turned round the pipe to make the desired bevel. As these cutters are usually designed to follow the contour of the pipe, and as the pipe has been pressed to a round form, the bevel preparation will be correct.



Twinner pipe expander.

When the pipe expander is removed the pipe walls usually return to their original ovality; thus, when the pipes are offered together for butt welding, it is necessary to press the walls of the pipes out again to the truly round shape from the inside. For this purpose a Twinner Internal Pipe Aligner is used.

The aligner, in the contracted position is capable of being propelled along the pipe wall on rollers. When it is in a position between the two pipes to be butt-welded it is expanded by turning the operating thrust screw by extension tubes. As the internal pipe aligner is expanded, it presses out the pipe wall to the same true roundness as was obtained by the pipe expander. The pressure exerted holds the two pipes together in perfect internal alignment and with the roots of the bevels matched evenly all round the pipes. The weld is now applied and when finished the aligner is contracted and rolled along the pipe for the next weld.



Twinner internal pipe aligner.

Provision is made in these aligners to accommodate copper backing rings if desired.

While primarily intended as an aid to cutting accurate pipe bevels, the pipe expander is also useful as a general purpose tool for holding cylindrical objects truly round while flanges or other fittings are welded on.

Both tools which are manufactured by Donald Ross & Partners Ltd., London, N.W.1, are made to suit any individual size of pipe from 6 in. upwards.

A NEW MICRO-BENDING TEST METHOD

(*Concluded from page* 211)

conditions by hardness and micro-bending tests reveals completely the condition of the material and permits of following the changes during heat treatment of the weld. The success of such treatment depends not so much on the decrease in hardness, which is fairly rapid, as on the increase in ductility, which lags behind the hardness change. Incomplete annealing results in lower strength, but not necessarily in increased ductility. The tendency of various steels to temper brittleness on welding can thus be investigated under restricted localised conditions. Similarly, the effect of cold work becomes apparent with this testing method.

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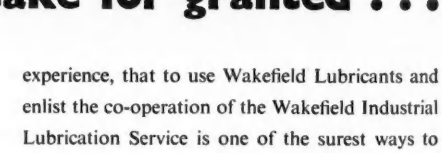
Similarly behind every Wakefield Industrial lubricant lies a long story of scientific achievement. That is why engineers take these oils for granted. They know that the final product that reaches them embodies the sum-total of all lubricating knowledge as it stands today. They know too, from experience, that to use Wakefield Lubricants and enlist the co-operation of the Wakefield Industrial Lubrication Service is one of the surest ways to cut down costs and increase efficiency.



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NEWS OF THE MONTH

PERSONAL

Mr. John Ayres, M.I.E.E., M.I.P.E., F.I.W.M., general manager of Petters Ltd., Staines, Middlesex, has been appointed managing director of the Company. **Mr. A. E. Carrodus** has been appointed to the Board as sales director.

Dr. Kurt Billig, M.I.C.E., M.I.Struct.E., has been appointed Director of the Central Building Research Institute of India, at Roorkee, India.

Sir Anthony Bowlby, director of Guest Keen & Nettlefolds (Midland) Ltd., and **Mr. A. B. Waring,** chairman and managing director of Joseph Lucas Ltd., have been elected vice-presidents of the Institute of Industrial Supervisors.

Mr. J. P. Broadbent has been appointed engineer-in-charge of the television transmitting station of the British Broadcasting Corporation, at Wenvoe, near Cardiff.

Mr. H. Burroughes, F.R.Ae.S., has been elected President of the Society of British Aircraft Constructors. **Mr. J. J. Parkes** has been elected vice-president, and **Mr. W. T. Gill,** deputy-president. **Sir Frederick Handley Page, C.B.E.,** has been re-elected honorary treasurer.

Mr. A. Kenneth Clyde, A.R.T.C., A.M.I.E.E., A.F.R.Ae.S., has been appointed assistant chief engineer of Tiltman Langley Laboratories Ltd., Redhill, Surrey.

Mr. Richards W. Cotton, vice-president and director of Philco International Corp., Philadelphia, has been appointed Director of the Electronics Division and Chairman of the Electronics Production Board, Defence Production Administration, Washington, D.C. He was for some time managing director of Philco, and is a director of Philco (Overseas) Ltd., London.

Mr. J. E. Elliott has been appointed research metallurgist to Bound Brook Bearings (G.B.) Ltd., Litchfield, Staffordshire. He was previously with the Development and Research Department of the Mond Nickel Co. Ltd., Birmingham.

Mr. Oliver W. J. Farmer has been appointed manager of Mazda lamp and lighting advertising for the British Thomson-Houston Co. Ltd., in succession to **Mr. H. E. Goody,** who is retiring at the end of July.

Lord Dudley Gordon, D.S.O., LL.D., and **Mr. James Alexander Jameson, C.B.E.,** have been elected Honorary Members of the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1.

Mr. Kenneth Gordon, C.B.E., M.C., deputy managing director of Head, Wrightson Processes Ltd., has been released to take up the post of Director General of Ordnance Factories, Ministry of Supply.

Mr. R. G. Harper, M.Sc. (Birm.), has been appointed technical manager to Fry's Metal Foundries Ltd., Tandem Works, Merton Abbey, London, S.W.19, and also to the Eyre Smelting Co. Ltd.

Mr. R. M. Hobill has been appointed transformer sales manager of Ferranti Ltd., Hollinwood, Lancashire, in succession to **Mr. G. B. Proctor,** who resigned. **Mr. H. G. Binns** has been appointed transformer contracts manager.

Dr. R. Jessel, B.Sc., A.R.C.Sc., F.Inst.P., A.M.I.E.E., has been appointed chief of the engineering division of Electronic Tubes Ltd., Kings Mead Works, High Wycombe, Bucks. **Mr. Kenneth Moore** has been appointed export sales manager, and **Mr. L. R. Thompson,** assistant sales manager.

Mr. N. D. Miles has been appointed general supply manager of Remington Rand Ltd., 1-19 New Oxford Street, London, W.C.1. He will be controlling the purchasing of materials for all Remington Rand factories under the supervisor of production.

Dr. C. J. Milner, head of the Physics Section, Research Laboratory, The British Thomson-Houston Co., Ltd., Rugby, has been appointed to the Chair of Applied Physics at the New South Wales University of Technology, Sydney, Australia, where he will be taking up duty in October.

Mr. H. P. Potts, managing director of B.S.A. Tools Ltd., Mackadown Lane, Marston Green, Birmingham, has been appointed a director of the Birmingham Small Arms Co. Ltd.

The following have been elected Chairmen of the local sections of the Institute of Metals for 1952-53. **Mr. H. H. Symonds, F.I.M.,** Birmingham; **Dr. C. E. Ransley, M.Sc., F.I.M.,** London; **Dr. H. M. Finniston, B.Sc., A.R.T.C.,** Oxford; **Mr. E. A. Fowler, B.Sc., A.R.T.C.,** Scotland; **Mr. M. M. Hallet, M.Sc., F.I.M.,** Sheffield; **Mr. K. M. Spring, A.I.M.,** South Wales.

Mr. Sam Smiley, F.C.C.A., A.A.C.C.A., F.C.I., Mr. J. Orwig Jones, A.M.I.Mech.E., and **Mr. Roy N. Fletcher** have been elected to the Board of Edward G. Herbert Ltd., Atlas Works, Levenshulme, Manchester 19. **Mr. Alan Kiernan, M.I.Mech.E., M.I.Prod.E.,** has been appointed assistant managing director, and **Mr. Tom Hitchens,** works manager of the Company.

Mr. E. V. Winstanley, B.Sc.Tech., M.I.Mech.E., chief engineer of the condenser and gear engineering department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17, has been transferred to the staff of the chief mechanical engineer for special duties. **Dr. W. H. Darlington, M.B.E., M.Sc., A.M.I.Mech.E.,** succeeds **Mr. Winstanley** as chief engineer of the condenser and gear engineering department.

Mr. H. E. Wright retired from the position of general manager of Steel, Peech & Tozer Ltd., Sheffield, but will continue to serve the Company in a consultative capacity. **Mr. Andrew Jollie,** hitherto general works manager, has been appointed general manager, and **Mr. G. E. D. Halahan,** formerly chief labour superintendent, succeeds **Mr. Jollie** as general works manager.

OBITUARIES

Mr. C. Leslie Fry, a local director of Thos. W. Ward Ltd., Sheffield, died on June 26th, while on holiday in the Scilly Isles. He was 52.

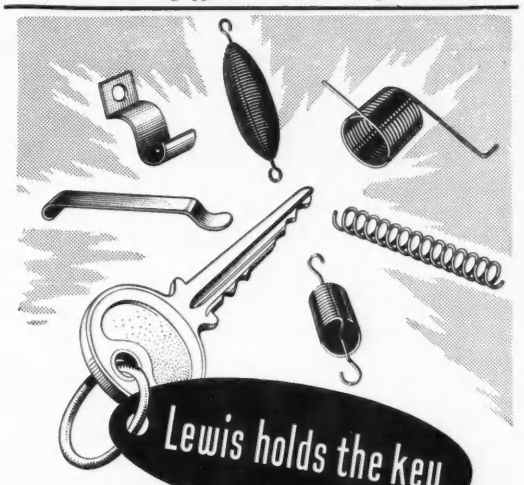
Mr. Fry was also joint managing director of Low Moor Best Yorkshire Iron Ltd., joint assistant managing director of the Wolverhampton Steel & Iron Co. (1946) Ltd., and a director of Birchley Rolling Mills Ltd.

Colonel W. C. Deveraux, C.B.E., F.R.Ae.S., managing director of Almin Ltd., chairman of International Alloys Ltd., Southern Forge Ltd., Warwick Production Co. Ltd., Structural and Mechanical Development Engineers Ltd., Fulmer Research Institute, director of Renfrew Foundries Ltd., and other companies, died on June 21st, at the age of 59.

Col. Devereux was a prominent industrialist and was probably the outstanding figure in the light metal industry.

After the first World War, realised the forthcoming importance of forged aluminium alloys, he formed High Duty Alloys Ltd. in 1927 to carry out research and development leading to the commercial production of the new high strength alloys needed by the aircraft industry. At the outbreak of World War II every R.A.F. aircraft used forged pistons and tribute was paid by the Air Minister in 1939 to the overwhelming importance of the technical developments and the facilities for production that had been built up by Col. Devereux, the quality of these achievements being reflected by the success of the Battle of Britain aircraft.

In 1945, conscious of the great strides taken by the aluminium industry and the need for a more broadly based organization, he founded the Associated Light Metal Industries Group spanning industry from raw material to finished product. During the past seven years this organization has undertaken manufacture of some of the most outstanding applications in aluminium yet conceived, in-



It isn't a magic key or anything like that. It just so happens that we have been called in on so many tricky questions over the last thirty years that we now know the answer to most of them. Wouldn't it be a good idea to see us about your new project? *Established 1919. A.I.D. approved.*

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The value of this work has received world-wide acknowledgement and has gained for this country leadership in these fields.

Holding that progress in light metal development rested principally on research, Col. Devereux always employed in his works a high proportion of research workers.

BUSINESS NOTES

Acheson Colloids Ltd., manufacturers of the well-known "dag" colloidal graphite and other dispersions, have opened a West of England office at 103 Promenade, Cheltenham. Telephone: Cheltenham 3847.

Foster Transformers & Switchgear Ltd., of Wimbledon (a "Lancashire Dynamo" Company) announce a change of name. The Company will in future be known as Foster Transformers Ltd. This development follows upon the transfer of switchgear manufacture to Bridgwater, Somerset, some twelve months ago and the formation there of a new Company—Lancashire Dynamo Switchgear Ltd. Fosters will continue to manufacture their extensive range of transformers, test equipment and voltage regulators.

Wild-Barfield Electric Furnaces Ltd. has opened their Canadian office at 72 Grenville Street, Toronto. Mr. J. E. Simpson is in charge of the Canadian office.

The International Radio and Electronics Exhibition of India, organised by the Radio and Electronics Society of India, will be held from 10th to 30th November.

Cannon Industries Ltd. has taken over, as from July 1st, the manufacturing side of Cannon Iron Foundries Ltd. All enquiries and correspondence should be addressed to Cannon Industries Ltd., Deepfields, near Bilston, Staffs.

The activities of the **Philco TechRep Consultants,** hitherto conducted from 93 Regent-street, London, W.1, will now be carried on from c/o Philco (Overseas) Ltd., Lion House, Richmond, Surrey. (Telephone: Richmond 5661).

Small and Parkes Ltd., Hendham Vale Works, Manchester, 9, have opened a new depot for "Don" brake and clutch linings, at 50, Old Market-street (Jacob-street entrance), Bristol. (Telephone: 27214).

British Insulated Callender's Cables Ltd. announce that their London branch stores have been removed to 10-14, White Lion-street, Islington, N.1. (Telephone: Terminus 8696-7). The branch office remains at 21, Bloomsbury-street, W.C.1.

The Corporation of Darlington have approved an outline plan by **Whessoe Ltd.,** of Darlington, for the construction of new industrial premises covering 20,000 sq. ft., at Darlington.

International Business Machines (United Kingdom) Ltd., a subsidiary of an American firm specialising in the manufacture of electrical office machines, have received approval from H.M. Government for the erection of a factory in the Kip Valley, Greenock.

The Radio Communication and Electronic Engineering Association, of which the secretary is **Mr. S. Neill Christie,** has moved from 59, Russell-square, to larger premises at 11, Green-street, London, W.1. (Telephone: Mayfair 7874-5).

The North British Locomotive Co. Ltd., Springburn, Glasgow, have acquired a controlling interest in **Henry Pels & Co. Ltd.,** makers of light machine tools, London, N.W.1. **Mr. T. A. Crowe,** chief managing director of the North British Locomotive Co., has been made chairman of Henry Pels & Co.

REVERSING UPWARD TREND OF COSTS IS GREATEST CONTRIBUTION TO THE NATIONAL ECONOMIC RECOVERY

Sir Patrick Hennessy, managing director of the Ford Motor Company Ltd., Dagenham, has issued the following Statement.

We, in company with many others, believe that the greatest contribution which can be made to the national economic recovery would be the halting and, if possible, the reversing of the upward trend of costs and selling prices at home and abroad.

Ford Motor Company Limited is the leading exporter in the Motor Industry, which, in turn, is the largest contributor to British exports. The average of the last 4 years' exports of British motor vehicles and tractors has been £173 million, and it is the avowed purpose of the Industry to maintain and, if possible, improve on this performance. It is our intention to play a full part in this important effort.

If exports are not maintained, production volume will fall and, unless something is done, unemployment and a lower standard of living will follow. We take the view that the future export position can best be safeguarded by ensuring that our products are sold at the lowest possible prices in markets which are becoming increasingly competitive.

In recent times some raw material prices have turned downwards, but on the other hand steel, our main raw material, has been going up, as indeed, have many others. In fact, our costs have been increasing. Despite the unfavourable factors, we think the time has come for courageous action and we have decided to make substantial price reductions, effective as from July 2nd. They are as follows:—*For Export:* Passenger Cars, 10%; Commercial vehicles, 7½%; Tractors, 5%.

Despite the fact that the home market is at present restricted, we are reducing prices on cars, commercial vehicles and tractors by 5%.

These price reductions have been under consideration for some weeks and we hope, and believe, that they may, in due course, act as a stimulus to export trade and as a contribution to the country's economic recovery and to the maintenance of full employment.

Full benefits can only be derived from price reductions of this kind if, as we hope, they are followed by similar action throughout Industry in general. This can be achieved only by a realistic acceptance on the part of all concerned that economy is absolutely imperative—now—to ensure continuity of employment and the essential expansion of our vital export trade.

NEW RADAR AID SCREENS APPROACHING AIRCRATF

Simple automatic radar control of airliners from the moment they approach the airfield to the point where they halt on the tarmac to unload passengers, has been brought a stage nearer by an airfield radar set which "screens" a picture of anything up to 15 miles round the control tower.

Using it, an operator can pick up an aircraft miles away from the airfield and instruct the pilot to join the circuit, bring it in to land and guide it round the taxitrack—all by following a "blip" on the screen and without looking out of the control tower window. It works regardless of weather and atmospheric conditions.

This Airfield Radar made by Cossor, is a development of earlier equipment which showed only the details of the airfield—down to cars and mechanics, and enabled airliners to be guided round taxi-tracks "blind-fold" in darkness or fog.

The advantage of the new equipment, besides its longer range, is that it is a comprehensive radar approach aid which is inexpensive and simple to operate and service. Its searching radar beam can be tilted up above ground obstacles, so that it scans only the level in which the aircraft is flying. As the aircraft descends, the beam is tilted downwards with it, and so brings more detail on to the screen. As the beam dips to ground-level, it shows all the details of the aerodrome taxi-tracks—with taxying aircraft, tractors, trucks and so on.

At present the set does not show height. The aircraft's altitude still has to come to the controller over the radio, relayed by the pilot. But the equipment is being adapted so that a model will shortly be available indicating height. It has been tested at Farnborough airfield, for some weeks and a large number of aircraft have been brought in to land using it.

IRON-ORE PLANT FOR YUGOSLAVIA.

A contract for a complete iron-ore handling plant to the value of over £1m. has been confirmed between The General Electric Co. Ltd., London, and Invest Import, Belgrade.

The plant, which is to have a capacity of 500/690 tons per hour, includes mechanical and electrical equipment and will be manufactured at the Fraser and Chalmers Engineering Works and the Witton Engineering Works of the G.E.C. Delivery to the Zenica Iron Works, Yugoslavia, is scheduled for two years.

This installation will form part of a complete iron-making plant, the consultants for which are Meckenzie Engineering Ltd., London.

SBAC FLYING DISPLAY AND EXHIBITION AT FARNBOROUGH

The 1952 SBAC Flying Display and Exhibition will be held at Farnborough, Hampshire, from Monday, September 1st to Sunday September 7th inclusive.

SEPT. 1ST MONDAY is a preview day reserved for technicians and Press and is *not* open to the public.

SEPT. 2ND, 3RD, and 4TH Tuesday, Wednesday and Thursday are guest days when the display is open *only* to those invited by the Society. It is *not* open to the Public on these days.

This year, to cater for the large numbers expected, there will be three public days instead of two—Friday, Saturday and Sunday, Sept. 5th, 6th and 7th. On each of these days the gates open at 10 a.m., flying is from 3 p.m. and the gates close at 7 p.m.

NEW BLAST FURNACE IN PRODUCTION IN HUNGARY

A new blast furnace in the industrial centre of Diósgyör, in Northern Hungary, will increase present pig iron production by more than one-third. It is the first blast furnace constructed in Hungary since 1938, and had been built in the record time of eight and a half months. In the next few years more blast furnaces would be built both in Diosgyor and in the new industrial centre of Sztálinváros, on the Danube.

Under the Five Year Plan, which began in 1950, Hungarian pig iron production is scheduled to increase from 398,000 tons to 1,280,000 tons in 1954. In the same period steel production is to increase from 860,000 tons to 2,200,000.

The BRUSH ABOE Group of Companies has received form the Australian Government an order for equipment worth more than £A500,000.

The order, received through the Group's Australian company, British Oil Engines (Australasia) Pty. Ltd., and placed by the Australian Department of Works and Housing, is for diesel engines and electrical equipment for vital defence projects.

Included in the order are seventeen 12-cylinder turbo-charged vee-form diesel engines (known as the JVS12) of 1140 bhp at 750 rpm, to be supplied by Mirrlees, Bickerton & Day, Ltd., of Stockport, Cheshire. These engines are coupled to alternators giving an output of 780 kW, to be supplied by The Brush Electrical Engineering Co. Ltd., of Loughborough, Leicestershire, together with Brush switchgear and other accessories. The equipment will be installed by the Group's own engineers.

The Telegraph Construction & Maintenance Co. Ltd. announce that arrangements are being made to move their Metals Division from Telcon Works, Greenwich, to the Satellite town of Crawley in Sussex where it is proposed to build a new factory for the production of their special alloys widely used in the electrical, radio and communications industries.

The first stage of the removal is not likely to take place for about eighteen months.

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HIGH SPEED HELICOPTERS

The next generation of British helicopters will have many of the features of efficiency and economy which come from being able to fly nearer the speed of the conventional aeroplane.

Development work is going ahead on a contract, placed by the Ministry of Supply, for a form of rotary-wing machine which is also driven along by conventional propellers. This will be based on the Rotodyne design developed by the Fairey Company.

The first flight of a machine combining the two principles will probably be from Bristol—a version of the twin-rotor Type 173 passenger helicopter, with stub wings, a retractable undercarriage and more powerful engines. British European Airways hope to operate this modified helicopter on some inter-city routes in Britain after the completion of tests.

It is thought likely that designs produced to B.E.A.'s large 40-seat helicopter specification will also incorporate fixed wings. One possible design has already been mentioned, the Type 181, a larger, faster, scaled up version of the 173. Other designs will probably feature gas-turbine engines.

Development of the Fairey Rotodyne principle is towards a 23-passenger " feeder-line " type of aircraft, driven forwards by two turboprop engines mounted on short, shoulder-high wings, but with jet propelled rotor blades mounted above the cabin. Air will be tapped from the two conventional turbopropeller engines, out along the blade tips, where separate reaction motors are mounted to give extra power for take-off and landing. Development work on these power units is now under way.

The fixed wings on all these designs take over some of the air lift from the rotor blades which can then turn faster to give more forward speed. There is a limit to the size of wing which can be added because the overhead rotor blades have to be tilted forward to take up the extra speed—and adding the wings introduces new aerodynamic effects.

When still more work has been done on this intermediate stage, designers will be turning to convertible aircraft, a hovering helicopter which can be converted to a high-speed fixed wing aircraft.

The designs fall into two classes—those in which the fuselage stays in its normal position however fast the convertiplane is flying, and those which take-off standing on the tail, rotate through 90° for the flight, and turn up on the tail again for landing.

LONDON FIRM'S NEW FACTORY IN NORTHERN IRELAND

The Northern Ireland Minister of Commerce states that negotiations with Wandleside Cable Works Ltd., London, for the establishment of a manufacturing unit in Northern Ireland have been brought to a successful conclusion. The Company, a subsidiary of Falk, Stadelmann & Co. Ltd., will occupy the new factory at Newcastle, Co. Down, and will commence the production of electrical cables there at the earliest possible date.

The Newcastle factory is one of the advance factories erected by the Ministry of Commerce in provincial centres. The factory comprises in all some 18,000 square feet and when in full production it is expected that employment will be provided for 180 workers of whom about two-thirds will be men.

" Filtration and Silencing " was the main theme of an Exhibition, arranged by Vokes Limited, of Guildford, in the Lesser Free Trade Hall, Manchester. Representative examples of various mechanisms, fitted with standardised Vokes filters and/or silencers, included a Perkins P.4 engine, for vehicular or industrial use, with Vokes oil bath air cleaner and full-flow lubricating oil filter; an Ailsa Craig RFR2 two-cylinder engine, for marine propulsion of light craft or for auxiliary power, with Vokes air and lubricating oil filters; a Napier T.S. 100 turbo-blower, as used for pressure charging high power engines for marine propulsion and stationary power plants, with Vokes annular air intake filter; a Jap Mark V industrial petrol engine, used for agricultural machinery, for electricity generation, or for pumping and other duties, with Vokes " Microvee " air intake filter; a Jaguar XK.120 car engine, the marque of international fame in competition, shown with Vokes air intake filter-silencer as fitted to the Jaguar Mark VII saloon; an Austin engine from the A.90 " Atlantic " car, with Vokes air intake filter-silencer and a Triumph 650 c.c. " Thunderbird " motor cycle with Vokes air intake filter.

A schematic presentation of a typical cabin air pressurisation system in a modern airliner, with Vokes cabin blower silencers and " Millevee " air intake filters, arranged with Normalair pressure control valves and Marshall superchargers was on show. In addition, a respresentative display of special filters for modern military and civil aircraft, including jet-propelled types, was included in the Exhibition.

A complete range of air cleaners developed by Vokes for the Fighting Vehicles Design Establishment of the Ministry of Supply, and a complete range of lubricating and fuel oil filters designed for the Admiralty, for use in destroyers, frigates, minesweepers and other classes of naval vessels, particularly those with compression ignition engines, were also displayed.

Vokes panel air filters, as used on the latest designs for British Railways and for many overseas systems, and as used in multiple installations to supply dust-free air inside power and pumping houses on the thousand mile oil pipe-lines of the Middle East, were also on show.

Other Vokes products shown included large marine and manifold silencers, pipe-line filters for compressed air and other systems carrying gases, petrol and fuel oil filters of all types. In quite different fields, the Vokes " Genspring " Constant Support Hanger for taking up thermal expansion and contraction in suspended pipe-lines in power houses and refineries, and the Vokes Ernst artificial leg, both manufactured by subsidiary companies, were also on view.

DESIGNERS USE HEAVY METAL TO SAVE WEIGHT.

Anyone who knows anything of the temperament of aircraft designers would be more than surprised to hear that one of them was searching for the heaviest metal he could find. Some designers have even gone to the length of having a heavy metal specillya manufactured. The explanation of this paradox is that, for certain special jobs, the designer uses the heaviest (or scientifically speaking, the highest-density) metal he can find because he knows that by doing so he actually saves on weight.

The job the metal has to do is to balance the wing and tail surfaces (elevators, ailerons and rudders) which are moved to control the aircraft. If these surfaces are not properly balanced, they might begin to flutter in flight.

The space in which the balances can be fitted is restricted. Often they go inside the ' nose ' of the control surface, and so the smaller they are, the better.

Besides saving space, heavy metal also saves weight, for this reason: if a metal balance of lighter weight were used, it would have to be larger and so its centre of action would be shifted nearer to the hinge, and thus its balancing effect would be less than required. To make this good, still more metal would have to be added and therefore more weight. This might also mean having to strengthen the structure of the wing and tail to take the extra weight—and so again, more weight.

A special Heavy Alloy is in fact manufactured for this job by the General Electric Co. It is 90 per cent. tungsten.

It is made by mixing the tungsten with nickel, copper and wax to bind it together, and pressing the mixture under 5-10 tons a square inch. When it comes out of the press it has something of the consistency of cigar ash, i.e. it just holds together.

It is then heated in a hydrogen atmosphere to 1,000° C, which removes the wax and hardens the compound—without changing its dimensions. Next, it is sintered in a furnace for fifteen minutes, during which time it shrinks by about 20 per cent., increases its density and becomes solid.

Lead is only sixty per cent. as dense as Heavy Alloy, which weighs twice as much as steel, but is just as strong.

STANDARDISED SCREW THREADS FOR SERVICE EQUIPMENT

Government Departments, with the co-operation of industry, are taking steps to stimulate the widest possible adoption of a unified system of screw threads for equipment supplied to the three Armed Services.

Action has already been taken in the case of new aero engines coming into production and ways are being worked out of applying the unified system of screw threads to airframe and aircraft equipment production. The Admiralty has already adopted the unified system for some types of armament and other equipment and regards

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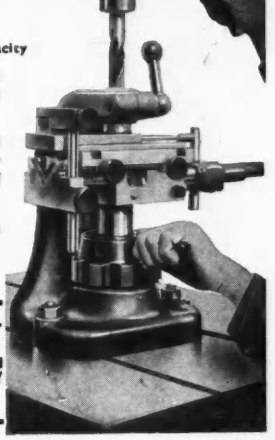

the wide adoption of unified standards as a development to be pursued as far and as soon as practicable. The Ministry of Supply is to ensure a wide application of the unified system for equipment and stores supplied to the Army.

The Services' policy on the adoption of unified screw threads jointly agreed was last expressed in a letter of 29th September, 1950, to the British Standards Institution from the Ministry of Supply. This reviewed the vital need for a common standard and unification with the United States and the Commonwealth. It described the efforts made, in full co-operation with Industry, which led up to the Declaration of Accord of 1948 with the United States and Canada, and it outlined a policy of gradual adoption of the system based on the British standard which gave effect to the Declaration of Accord.

Since that date the need for a common standard and unification has become increasingly manifest and agreement has been reached throughout the Services and Industry on British standards for bolts and nuts with unified threads (BS. 1768 and 1769), and for screw thread gauge tolerances (BS. 919), screwing taps (BS. 949), and spanners for use with unified bolts and nuts (Amendment No. 1 to BS. 192). Provision is also being made for the range to be extended below ¼ inch diameter for screws for attachment of components.

The result of this work has facilitated the production in this country of screwing tackle for the agreed ranges of sizes and pitches for nuts, bolts, and screws and corresponding spanner sizes in the unified range, and this is now becoming available for reasonable delivery.

It has all along been recognised that progress on the adoption of the unified thread for Service equipment is dependent upon mutual action with Industry, and that manufacturers and their sub-contractors must, therefore, be encouraged to provide themselves with taps, dies and other screwing tackle for the unified system.

The policy of the Service Ministries is to adopt the unified screw thread system as general practice throughout the Services, even for items of an essentially commercial nature. It is, in consequence, hoped that manufacturers will, in the light of this knowledge, be encouraged to turn over to a more general adoption of the unified screw thread system, so as to bring commercial and Service practice into line.

BRITISH STANDARDS

(Copies of British Standards may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.1)

Flanged Steel Check Valves for the Petroleum Industry B.S. 1868 : 1952 covers cast or forged steel check valves, with integral flanges, of the swing, piston and ball types, the seat rings being renewable and either shoulder-seated or bottom-seated. The permissible pressure is a maximum of 1000 lb/sq. in. for valves of Class 300 and above for valves 1-18 in. size.

It includes provisions relating to design and manufacture, materials, workmanship, marking, tests, inspection, despatch and guarantee.

The specification is supported by a number of appendices and six detailed drawings illustrating the valves covered and providing identification of the various parts of the valves. Price 10/6.

Glossary of Terms used for Solid Fuel Burning and Allied Appliances. B.S. 1846 : 1952 was prepared at the request of the Combustion Engineering Association. The principal object in view was the covering of as large a field as practicable in connection with appliances burning solid fuel. Included are definitions of cooking, space heating and water heating appliances, steam boilers, pulverized fuel and gasification plant. A comprehensive index is provided. Price 3/-.

Shear Bolts and Nuts for Aircraft. B.S. A.57/58 : 1952 relate to the material, dimensions, finish and identification of close tolerance, hexagonal headed shear bolts and slotted and thin hexagonal nuts in high tensile steel for use on aircraft. Price 3/-.

Methods for the Analysis of Aluminium and Aluminium Alloys—Part 4 : Zinc (Polarographic Method). B.S. 1728 : 1952 is an alternative to the mercuric thiocyanate method already published (Part 3). As with polarographic methods in general, it is particularly useful for alloys having a low zinc content and, over a range of 0.02 to 3 per cent. zinc, gives results having close agreement with the mercuric thiocyanate method.

The method specifies the reagents used, recommended methods of sampling and test procedure. An indication of the reproducibility expected is given and is derived from experiments carried out by a number of independent analysts. Price 2/-.

Screw Thread Gauge Tolerances. B.S. 919 : 1952 furnishes tolerances for gauges for Unified screw threads and makes recommendations for a new approach to gauging practice based on the principle of having a general " Go " gauge with its tolerance zone inside the work limits in place of the former " workshop " and " inspection " gauges. Provision is also made for a reference " Go " gauge which is intended for use by manufacturers and inspectors as a control on the performance of their general gauges.

Tolerances are specified for screw gauges and setting plugs for screw threads in the regular series such as B.S. Whitworth, B.S. Fine, B.S. Pipe (Parallel threads), UNC, UNF, Metric (S.I.) and B.A. etc.; they may also be applied to gauges for any screw threads of Whitworth Unified or Metric (S.I.) form.

General requirements are given for all types of gauges used for checking external and internal threads and for setting plugs for screw ring and thread calliper gauges. The text includes an explanation of the uses of the various types of gauges and the dispositions of their tolerance zones. Examples of the application of the tables are given in an appendix and forms of thread for " Go " screw gauges and " Not Go " effective diameter gauges and setting plugs are illustrated. Price 5/-.

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